G. R. Howell

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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 64
1954

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BENJAMIN MOULTON, EDITOR
Butler University
Indianapolis 7, Ind.

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Spring Meeting
May 14-15
POKAGON STATE PARK

Fall Meeting
October 14-16, 1954
PURDUE UNIVERSITY

Published at Indianapolis, Indiana
1955

1. The permanent address of the Academy is the Indiana State Library.

2. **Instructions for Authors** appear at end of this volume, p. 295.

3. **Exchanges.** Items sent in exchange for the Proceedings and correspondence concerning exchange arrangements should be addressed:

Indiana Academy of Science, Library
c/o State Library, Indianapolis 4, Indiana

4. **Proceedings** may be purchased through the State Library at $3.00 per volume.

5. **Reprints of technical papers** can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

6. The Constitution and by-laws reprinted from v. 62 and the Membership list reprinted from v. 61, are available to members upon application to the Secretary. Necrologies reprinted from the various volumes can be supplied relatives and friends of deceased members by the Secretary.

7. Officers whose names and addresses are not known to correspondents may be addressed care the State Library. The address of the editor of the present volume is Department of Geography, Butler University, Indianapolis, Ind.

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OFFICERS AND COMMITTEES FOR 1954

OFFICERS

President	O. B. Christy, Muncie, Indiana
Vice-President	Raymond Girton, Purdue University
Secretary	W. A. Daily, Eli Lilly and Company
Treasurer	F. J. Welcher, Adult Education Center, Indiana University
Editor	Benjamin Moulton, Butler University
Press Secretary	J. A. Clark, Department of Conservation, Indianapolis

DIVISIONAL CHAIRMEN

Anthropology	Thomas B. Noble, Indianapolis
Bacteriology	Dorothy Powelson, Purdue University
Botany	Richard Starr, Indiana University
Chemistry	R. G. Larson, Valparaiso University
Entomology	Paul T. Ulman, Noblesville
Geology and Geography	Benjamin Moulton, Butler University
History of Science	M. S. Markle, Earlham College
Mathematics	Ralph Hull, Purdue University
Physics	George D. Van Dyke, Earlham College
Psychology	Edward T. Jordan, Indiana State Teachers College
Zoology	John D. Mizelle, University of Notre Dame

EXECUTIVE COMMITTEE

(Past Presidents, Current Officers, Divisional Chairmen,
and Chairmen of Standing Committees)

W. P. Allyn, O. B. Christy, J. A. Clark, N. M. Coats, Sears Crowell, E. R. Cumings, Mrs. F. K. Daily, W. A. Daily, J. J. Davis, Ed. Degering, D. DenUyl, W. E. Edington, P. D. Edwards, H. E. Enders, R. Girton, R. Hull, E. T. Jordan, T. K. Just, J. S. Karling, R. G. Larson, R. W. Lefler, Eli Lilly, J. F. Mackell, M. S. Markle, M. G. Mellon, H. H. Michaud, J. D. Mizelle, W. P. Morgan, B. Moulton, T. B. Noble, F. Payne, C. L. Porter, H. M. Powell, Dorothy Powelson, R. R. Ramsey, R. C. Starr, P. T. Ulman, G. D. Van Dyke, S. S. Visher, F. N. Wallace, P. Weatherwax, Winona Welch, F. Welcher, T. G. Yuncker.

BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairmen of
Committees on Junior Academy, Library, Program
and Relation of Academy to State)

O. B. Christy, W. A. Daily, F. J. Welcher, B. Moulton, H. H. Michaud, N. M. Coats, J. S. Karling and F. N. Wallace.

COMMITTEES ELECTED BY THE ACADEMY

Trustees of the Academy Foundation (term four years): Chairman, R. N. Harger, Indiana University School of Medicine, Indianapolis (term expires 1956); W. J. Rice (term expires 1955).

Bonding of Trustees (elected annually): Chairman, Scott McCoy, Technical High School, Indianapolis; W. P. Morgan.

Research Grants (term 5 years): Chairman, T. G. Yuncker, DePauw University (term expires 1954); W. H. Johnson (1957), M. G. Mellon (1955), P. Weatherwax (1956), J. F. Mackell (1958), O. B. Christy and W. A. Daily (ex officio).

STANDING COMMITTEES

(Appointed by the President)

Auditing: Chairman, W. P. Morgan, Indiana Central College; S. E. Elliott.

Biological Survey: Chairman, Mrs. F. K. Daily, Butler University; H. J. Brodie, F. Buser, D. G. Frey, H. H. Michaud, S. A. Minton, F. N. Young, W. Welch.

Fellows Committee: Chairman, P. D. Edwards, Mathematics, Ball State Teachers College; C. F. Voeglin, Anthropology; H. M. Powell, Bacteriology; W. Welch, Botany; F. J. Allen, Chemistry; G. E. Gould, Entomology; A. H. Meyer, Geology and Geography; S. S. Visher, History of Science; J. F. Mackell, Physics; F. D. Brooks, Psychology; W. R. Breneman, Zoology.

Index: Chairman, B. Moulton, Butler University; N. M. Coats, F. N. Wallace, Paul Weatherwax.

Indiana Talent Search: Chairman, R. W. Lefler, Purdue University; L. H. Baldinger, T. W. Torrey and P. D. Edwards. W. Leckrone and O. B. Christy (ex officio).

Invitations: Chairman, J. D. Mizelle, Notre Dame University, R. L. Hicks, T. G. Yuncker.

Junior Academy: Chairman, H. H. Michaud, Purdue University; N. E. Adams, W. H. Carnahan, R. Cooper, Paul Klinge, R. McDougal, R. E. Martin, R. E. Niswander, J. E. Potzger, M. L. Stork, P. L. Whitaker.

Library: Chairman, N. M. Coats, Indiana State Library; M. G. Mellon, Eli Lilly.

Membership: Chairman, D. DenUyl, Purdue University; M. Burton, J. O. Cottingham, H. E. Crull, M. Garner, W. H. Headlee, R. L. Hicks, Z. D. Hurlbut, W. D. Kessel, E. Kintner, R. Laubengayer, L. S. McClung, R. E. Martin, A. H. Meyer, D. E. Miller, J. Seybert, A. Strickler, H. R. Youse.

Necrologist: W. E. Edington, DePauw University.

Program: Chairman, J. S. Karling, Purdue University; J. A. Clark, C. J. Goodnight, A. T. Guard, A. A. Lindsey, H. H. Michaud, B. Moulton, J. E. Potzger, D. Powelson.

Publication of Proceedings: Chairman, B. Moulton, Butler University; A. A. Lindsey, P. Weatherwax.

Relation of Academy to State: Chairman, F. N. Wallace, State Department of Conservation; J. A. Clark, Eli Lilly, H. J. Reed.

Representative on Council of the A.A.A.S.: Sears Crowell, Indiana University.

Resolutions: Chairman, W. P. Allyn, Indiana State Teachers College; F. Hurlbut, T. G. Yuncker.

MINUTES OF THE SPRING MEETING

Pokagon State Park

Potawatomi Inn, Angola, Indiana

May 14-15, 1954

President O. B. Christy called the Executive Committee Meeting to order at 4:30 P. M. in the Potawatomi Inn.

The officers and committees reported as follows:

Press Secretary: James Clark mentioned that the usual news releases had been made.

Editor: Benjamin Moulton stated that the Proceedings for 1953 would probably be ready for distribution in July. There would be 1,200 hard covers and 600 paper bound volumes.

Library: Nellie Coats sent the following report to the Secretary: The library continues to expand both in volume and in range. Twenty-nine new titles have been added during this period. Binding has been deferred pending a further study of Academy finances.

Old Business:

1. A. A. Lindsey, K. Shockley and J. O. Cottingham discussed the work of the Natural Areas Preservation Committee. It was moved and approved that the Trustees of the Academy Foundation be requested to furnish the funds for obtaining an option on the Pine Hills Area and the Academy Council be authorized to act.
2. J. E. Potzger reported by correspondence that the John Shepard Wright Memorial Library Plaque has now been put in place in the State Library Building.

New Business:

1. J. O. Cottingham read the following proposal which was moved and approved; that the Plant Taxonomy Section become a recognized section of the Indiana Academy of Science.
2. Daniel J. O'Grady discussed the status of the Indiana Psychological Association in relation to the Academy. This matter has been deferred until the Fall Meeting. The I. P. A. intends to meet with the Academy this fall.
3. The advisability of continuing the "Distinguished Paper" awards was deferred until the Fall Meeting.
4. The possibility of including the name of the Junior Academy on the cover of the Academy programs was raised by the secretary. This is to be referred to the Chairman of the Program Committee.

All reports were accepted. The meeting adjourned at 6:00 P. M.

Dinner Meeting: Following the dinner in Potawatomi Inn, the business session was called to order by President Christy in the lounge at 7:45 P. M.

1. James F. Mackell gave a short but interesting sketch concerning the career of Charles R. Dryer who is commemorated in Pokagon State Park.

2. A report of the Executive Committee Meeting by the secretary was approved by the Academy.

3. Announcements of the field trips to be taken the next day were given by the leaders.

4. J. O. Cottingham reported that 15 applications for membership had been received. These were duly acted upon and the applicants accepted for membership in the Academy.

5. Dr. Donald Stulken of Purdue University gave a very interesting illustrated talk on the survival and distribution of otters in the Aleutian Islands.

6. Stanley E. Hartzell gave a timely and thought-provoking talk on "Germ Warfare."

Eighty-five members signed the Academy roll.

All scheduled hikes were made on May 15 in very fine weather.

W. A. DAILY,
Secretary

MINUTES OF THE EXECUTIVE COMMITTEE

PURDUE UNIVERSITY, OCTOBER 14, 1954

The Executive Committee of the 70th session was called to order by President Christy in the East Faculty Lounge of the Union at 7:15 P. M.

The minutes of the Spring Meeting, held at Pokagon State Park, were read and approved.

The reports of officers and committee representatives were presented and accepted as follows:

Treasurer's Report

January 1, 1954 to December 31, 1954

Receipts

Balance on hand January 1, 1954	$1,845.68	
Dues and initiation fees	2,071.00	
Publications sold	76.62	
A.A.A.S. refund for research grants	460.00	
Author's reprints, Vol. 61	28.20	
Author's reprints, Vol. 62	60.49	
Author's reprints, Vol. 63	473.59	
Sale of printed envelopes—Fay Daily	11.00	
Binding Proceedings for members	43.00	
		$5,069.58

Disbursements

1.	Editor Vol. 63	$ 200.00	
2.	Expenses of Secretary	137.44	
3.	Expenses of Treasurer	150.26	
4.	Stationery	204.75	
5.	Program Committee	311.97	
6.	L. S. McClung Research grant	50.00	
7.	J. E. Potzger Research grant	62.50	
8.	J. M. Wood Research grant	100.00	
9.	Winona H. Welch Research grant	50.00	
10.	Publication of Proceedings Vol. 63	241.74	
11.	Author's reprints Vol. 62	400.00	
12.	Author's reprints Vol. 63	593.23	
13.	Postage and packaging Author's reprints	26.76	
14.	Refund on payment for Author's reprints to L. H. Monaco	10.32	
15.	Bronze plate—John H. Wright Memorial Library	60.00	
16.	Walnut stand for same	50.00	
17.	Expenses Junior Academy of Science	44.45	
18.	Expenses of President	11.87	
19.	Mailing Proceedings, Vol. 63	109.11	
20.	Returned Checks	4.00	
21.	Expenses of five officers as directed by action of 1947 Executive Committee	100.00	
22.	Binding for Academy of Science Library	697.00	
		3,615.40	
	Balance on hand December 31, 1954	1,454.18	
			$5,069.58

Balance includes $61.30 remaining in treasury from grant for preparation of manuscript of Indiana Scientists.

FRANK J. WELCHER, Treasurer

Press Secretary. James Clark reported that two releases were sent to the larger state newspapers and those in college towns. Radio stations, college and university publications, likewise, were sent releases. Articles of general appeal were included in the latter mailing. National scientific magazines were sent a release well in advance of publication.

Editor and Publication of Proceedings. Ben Moulton stated that the Proceedings of the Indiana Academy of Science Vol. 63 were issued in July. The Bookwalter Company has made adjustments on the cost of reprints for Vol. 62. Cost of reprints for Vol. 64, 1955, will approximate those of Vol. 63 published this year.

Trustees of the Academy Foundation. The secretary presented the tentative report for the year 1953-1954:

Assets as of October 1, 1954	$12,406.00
One $1,000 U. S. Treasury Bond on order	1,000.00
Cash balance at the Indiana National Bank	475.27

Research Grants. T. G. Yuncker reported as follows: Four grants were made during the first of the year:

1. Dr. L. S. McClung, Indiana University—$100 for use in studies in connection with Clostridia.
2. Dr. J. E. Potzger, Butler University—$125 to assist in continuation of bog pollen studies in northern Canada.
3. Mrs. Fay K. Daily, Butler University—$70 to help defray cost of preparation and distribution of a questionnaire in connection with the Biological Survey Committee of the Indiana Academy of Science and publication of the results.
4. Dr. S. S. Visher, Indiana University—$50 to assist in a study of population changes in Indiana.

A recent application from Joseph M. Wood of Indiana University for $100 in connection with his studies of plant fossils was approved.

An application from Winona Welch of DePauw University for $100 was approved. This is to aid in assembling literature, photostats, etc., in connection with the beginning of a monographic study of the Hookeriaceae-family of mosses.

Nominations. T. G. Yuncker was recommended to serve another term of 5 years as chairman of the Research Grants Committee. It was recommended that Scott McCoy continue as chairman of the Bonding Committee and W. P. Morgan serve as the second member.

Biological Survey. Fay K. Daily reported that a questionnaire to obtain the names and activities of workers in Biological Survey in Indiana was sent to all members of the Indiana Academy of Science in April, 1954. It was requested that completed questionnaires be returned before November 1, 1954. A tabulation of the results of the questionnaire follows on page 20. This work was made possible by a research grant from the American Association for the Advancement of Science which is sincerely appreciated.

Fellows Committee. P. D. Edwards reported as follows: The Fellows Committee of the Indiana Academy of Science met in Harrison Hall, DePauw University, Sunday, October 3, 1954.

After due deliberation, the following named members of the Academy were chosen by unanimous vote of the committee members present. These names are presented to the Executive Committee with the recommendation that they be elected as Fellows of the Indiana Academy of Science:

Dr. William Hugh Headlee, Department of Microbiology, Indiana University School of Medicine.
Dr. Charles B. Heiser, Department of Botany, Indiana University.
Professor Earl T. McBee, Department of Chemistry, Purdue University.
Professor Edward L. Haenish, Department of Chemistry, Wabash College.
Professor Frank T. Gucker, Department of Chemistry, Indiana University.
Professor Ernest E. Campaigne, Department of Chemistry, Indiana University.
Professor Mark Curtis Wilson, Department of Entomology, Purdue University.
Professor A. R. Addington, Department of Geology and Geography, Fresno State College.
Dr. James R. Anderson, Bureau of Agricultural Economics, U. S. Department of Agriculture.
Professor Harry E. Crull, Department of Mathematics, Butler University.
Professor Tracy Y. Thomas, Department of Mathematics, Indiana University.
Dr. J. B. Hershman, President, Valparaiso Technical Institute.
Professor A. C. G. Mitchell, Department of Physics, Indiana University.

Inasmuch as the Plant Taxonomy Section has been added to the established sections of the Academy, it is recommended that the new President appoint a member of that section to serve on the Fellows Committee.

A motion was approved that Section (m) on Fellows of the By-Laws should be altered. Paul Weatherwax suggested the following: Each active section shall be represented. The order of rotation already established is recognized. Representatives of new sections shall be added at end of list. Each year the two members at the top of list shall be dropped and two new ones representing same sections shall be added at the end of the list. When any section is discontinued by action of the Academy, the member representing that section shall be dropped from the list.

Indiana Science Talent Search. R. W. Lefler sent the following report to the Executive Committee:

College recognition of winners and participants in the Indiana Science Talent Search continues strong. Ninety-six of the ninety-eight 1953-1954 participants have reported. They have received financial aid in excess of $51,000 for the four-year undergraduate program. They are attending thirty-one colleges and three nursing schools. Sixteen Indiana colleges are represented in this group. All excepting four of the 96 students reporting are in school.

The Indiana Search provides much stimulation to these students to enter college since it introduces every participant to each Indiana college through the Committee's reports to the colleges. This stimulation plus the financial aid usually made available by the colleges to students on the basis of need has been over recent years a prime factor in causing nearly 100% of the participants to continue their education.

The Search for 1953-1954 was again financed by *The Indianapolis Times*. Mr. Leckrone, Editor of the *Times*, has, however, found it necessary to reduce financial support for the coming year to $500. This means that the Indiana Science Talent Search Committee must "find" about $1,500 to continue the activity on the basis to which it has been accustomed.

Junior Academy. H. H. Michaud reported as follows:

The twenty-first annual meeting of the Indiana Junior Academy of Science was held Saturday, November 7, 1953, in the new Science Hall of Earlham College, Richmond. Two hundred fifty club members, sponsors and guests registered for the meeting. There are now about forty-five clubs listed on our roll.

Four new clubs have been added since the beginning of this school year. They include the Alchemists, Edinburg High School; the Science Club, Hamlet High School; the Science Club, Rossville High School, and the Up and Atom Club, Sandborn High School. It is especially noteworthy that some of the smaller high schools are showing an interest in science club activities.

An unusual and different program has been prepared for the Junior Academy this Saturday in combination with the Purdue Sci-Math Assembly. The morning program will include science exhibits and projects by high school club members, visits to instructional and research laboratories of Purdue University, and a conference on careers in science and mathematics. High school students will be given the opportunity to confer with specialists about projects which they have started or expect to start.

Library. Nellie Coats reported that in addition to the general search for new publications that may be acquired by exchange for the Academy's library, lists of scientific serials published in the Indo-Pacific area and in the Middle East were checked. During this year, fifty-three new titles have been added expanding the subject and geographic range of the collection. The acquisition of a nearly complete file of the Hawaiian Academy of Science Proceedings is particularly gratifying.

New equipment for recording material received by the Academy has been purchased by the State Library.

The Proceedings Vol. 63 for 1953, publication date June 29, 1954, was distributed to members, the State Library absorbing the cost of envelopes and labor.

In connection with the editor's project for binding paper backed issues of the Proceedings it was possible to supply from storage 56 earlier issues for sale to members.

Mrs. Harold Burton, Serials Librarian, prepared 204 volumes for binding, bringing the total of bound volumes to 4,870.

Relation of the Academy to State. Frank N. Wallace sent the following report: The appropriation request to the coming legislature is for

$4,000.00. This is an increase of $500.00 per year. I believe the Budget Committee will grant this increase for the Academy Proceedings.

Representative on the Council of the A.A.A.S. Sears Crowell attended the Boston meetings and reported the following:

The full account of the meetings of the Council are available in the journal *Science*, Feb. 19, 1954. Nothing of immediate concern to our Academy was contained therein. A substitute for Dr. Crowell will be necessary for this year's meeting to be held at Berkeley, Calif.

Old Business.

1. Natural Area Preservation. A. A. Lindsey reported that much progress has been made in relation to the possible acquisition of two areas of land, namely, Pine Hills and Englishton Park.

A motion was approved that the Committee assume the status of a "Standing Committee."

A motion was approved that the committee be authorized to act upon acquisition of the Englishton Park area.

A motion was approved that a special fund be established for the National Areas Preservation Committee to be maintained by gifts solicited from Academy members and others for the buying and maintenance of land.

No general funds of the Academy or funds of the Academy Foundation other than already authorized are to be used by the committee.

W. A. DAILY, Secretary.

MINUTES OF THE GENERAL SESSION

PURDUE UNIVERSITY, OCTOBER 15, 1954

The minutes of the Executive Committee were read and approved.

President Frederick L. Hovde of Purdue University welcomed the Academy to their campus. A response was given by O. B. Christy, president of the Academy.

W. E. Edington presented a short biography of the members who had died during the year. These were: Harry F. Dietz, Karl B. McEachron and Frederick L. Serviss.

Dr. W. R. Brenneman of Indiana University then gave an extremely interesting illustrated lecture entitled "Kalamazoo to You."

The meeting adjourned at 11:00 A. M.

Sectional meetings then began with a recess for lunch served in the basement cafeteria of the Union, after which meetings were resumed.

The annual dinner was held in the North Ballroom of the Union.

Several delightful musical numbers were rendered by Miss Lois Goodman, xylophonist; Mr. David Wilcox, accordionist; Mr. Robert Tam, vocalist, and Miss Ann Dyer, accompanist.

R. E. Girton, vice-president, then presented those sitting at the speakers' table to the dinner guests.

T. G. Yuncker read the report prepared by the Resolutions Committee.

We, your Resolutions Committee, wish to extend the thanks of the entire membership of this Academy to Dr. Karling and members of his Program Committee for the splendid arrangements provided at this meeting.

The comforts of the members of the Academy, including rooms for committee, sectional and other meetings, as well as housing and food, have been adequate and excellent.

The Academy, likewise, is grateful for President Hovde's warm words of welcome to Purdue and his sympathetic attitude toward the aims and objectives of the Academy.

The cordial hospitality and wonderful entertainment provided by Purdue University and its staff is deeply appreciated.

Daniel DenUyl presented the names of 35 applicants for membership. These were duly elected.

R. H. Cooper reported that the Academy had been invited to meet on the University of Notre Dame campus, Oct. 13-15, 1955.

The Nominations Committee report was given by the chairman, H. M. Powell. Divisional Chairmen for 1955 will be: Anthropology, John Jones, Indiana University; Bacteriology, H. A. Dettwiler, Eli Lilly and Company; Botany, A. L. Delisle, University of Notre Dame; Chemistry, John A. Buehler, Anderson College; Entomology, Donald W. Hamilton, 1237 Washington Ave., Vincennes, Ind.; Geology and Geography, William J. Wayne, Indiana University; History of Science, B. E. Montgomery, Purdue University; Mathematics, Harry E. Crull, Butler University; Physics, Dr. Francis E. Throw, Wabash College; Plant Taxonomy, A. A. Lindsey, Purdue University; Psychology, Barron B. Scarborough, DePauw University; Zoology, Jackson Webster, Hanover College.

The following members were recommended to serve as the officers for 1955: President, A. H. Meyer, Valparaiso University; Vice-President, Willis Johnson, Wabash College; Secretary, W. A. Daily, Eli Lilly and Company; Treasurer, Frank Welcher, Adult Education Center, Indiana University, Indianapolis; Editor, Ben Moulton, Butler University; Press Secretary, J. A. Clark, Department of Conservation, Indianapolis.

The seventieth annual meeting of the Indiana Academy of Science with a general attendance of 425 and a dinner attendance of 150 was adjourned.

W. A. DAILY, Secretary.

NEW MEMBERS 1954[1]

Beekman, Bruce Edward, Department of Zoology, Indiana University, Bloomington, Ind.	Z
Bernard, Sister Marie, O.S.F., Marian College, 3200 Cold Spring Rd., Indianapolis 22, Ind.	Bo, Z
Berry, Jewel Edward, 509 E. Howard, South Bend, Ind.	Z
Brookley, Arthur C., Jr., Indiana Geologic Survey, Bloomington, Ind.	G
Bundy, Wayne M., Geological Survey, Indiana University, Bloomington, Ind.	G
Crider, Mrs. Elizabeth H., 1110 W. Kessler Blvd., Indianapolis, Ind.	B, Z
Dillon, Lowell I., A-2, Hoosier Ct. Exp., Bloomington, Ind.	G
Dineen, Dr. Clarence F., Biology Department, Notre Dame University, Notre Dame, Ind.	Z
Fielder, William L., 4915 W. Pine, St. Louis, Mo.	C
Fitzwater, William D., Jr., A.E.S. Annex, West Lafayette, Ind.	Z
Frith, Dr. William C., 39 Bridgemont Whaley Bridge, NR, Stockport, Cheshire, England	C
Gallun, Robert L., 240 Schilling Dr., West Lafayette, Ind.	E
Garrison, William A., University Apts., W-109, Bloomington, Ind.	G
Gray, Henry H., 822 E. Hunter Ave., Bloomington, Ind.	G
Griffin, Charles D., 630 W. 41st, Indianapolis, Ind.	Bo
Gunther, Prof. W. C., Valparaiso University, Valparaiso, Ind.	Z
Heatwole, Harold F., Goshen College, Goshen, Ind.	Z
Herbst, Eugene L., 229 Floyd St., Elkhart, Ind.	C
Hosler, Dr. Peter, Eli Lilly and Co., Indianapolis, Ind.	Ba, C
Huling, Prof. Richard T., Franklin College, Franklin, Ind.	Z
Hunnings, Keith, 815 Park Ave., New Haven, Ind.	C
Hutton, Kenneth E., Department of Biological Sciences, Purdue University, Lafayette, Ind.	Z
King, Dr. Lawrence J., Boyce Thompson Institute, 1086 N. Broadway, Yonkers, N. Y.	Bo, H
Kingsolver, John M., G-65-A Stadium Terrace, Champaign, Ill.	E
Lange, Lester H., Valparaiso University, Valparaiso, Ind.	M
Lytle, Charles F., Department of Zoology, Indiana University, Bloomington, Ind.	Z
Madison, James A., 701 E. Seminary St., Greencastle, Ind.	G
Mahan, Robert, 244 Home Ave., Elkhart, Ind.	Ph
Mayfield, Robert Charles, 314 E. 6th, Bloomington, Ind.	G
Miller, Paul F., 1106 Washington St., Valparaiso, Ind.	G
Moran, Joseph F., Jr., Department of Biology, University of Notre Dame, Notre Dame, Ind.	Z
Murray, Dr. Raymond W., C.S.C., Department of Sociology, University of Notre Dame, Notre Dame, Ind.	A
O'Grady, Dr. Daniel C., Box 132, Notre Dame, Ind.	Ps

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[1] Abbreviations following the members' listings indicate the sections of the Academy with which they are affiliated.

Orpurt, Dr. Philip A., Biology Department, Manchester College, North Manchester, Ind. Bo

Overstreet, Rose Alice, Botany Department, Indiana University, Bloomington, Ind. Bo

Pierson, Ralph C., 5924 Grandview Dr., Indianapolis 20, Ind. Z

Roberts, Claude M., U. S. Geological Survey, 311 W. Washington St., Indianapolis, Ind. G

Rosenshein, Joseph S., 34 S. Rangeline Rd., Carmel, Ind. G

Salter, Lewis S., Wabash College, Crawfordsville, Ind. Ph

Shallenburg, Mrs. John, Richmond Senior High School, Richmond, Ind.

Shaner, Elizabeth L., 617 W. Lexington Ave., Fort Wayne 6, Ind. Z

Singleton, Dr. J. R., Department of Biological Sciences, Purdue University, Lafayette, Ind. Bo

Smith, Mrs. Fred S. (Elsa Holzwarth), 6840 Dover Rd., Indianapolis 20, Ind. G

Stephenson, William K., Earlham College, Richmond, Ind. Z

Van Dyke, Prof. George D., Earlham College, Richmond, Ind. Ph

Vig, Reuben J., 3023 W. Morris, Indianapolis, Ind. G

Wagenknecht, Burdette L., 1610 Francis St., Franklin, Ind. Bo

Weber, Walter, 47 S. Pennsylvania St., Indianapolis, Ind. E, Bo, C

Wrathall, James E., Department of Geography, Indiana University, Bloomington, Ind. G

Zimmerman, Elaine, 344 W. Oak St., West Lafayette, Ind. C

Junior Academies

Chesterton High School Science Club, Chesterton High School, Chesterton, Ind.

The Alchemists of Edinburg High School, Edinburg High School, Edinburg, Ind.

George Washington High School Science Club, George Washington High School, 2215 W. Washington St., Indianapolis, Ind.

Science Club of Hamlet Jr.-Sr. High School, Hamlet School, Hamlet, Ind.

Phi Chi Science Club, New Haven High School, New Haven, Ind.

Science Club of Rossville High School, Rossville High School, Rossville, Ind.

Up and Atom Science Club of Sanborn High School, Sanborn High School, Sanborn, Ind.

REPORT OF THE BIOLOGICAL SURVEY COMMITTEE

The symbols following the names of workers in this field have the following meaning: PP, published in the Proceedings of the Indiana Academy of Science, abstracts included; PE, published elsewhere; CP, maintains a personal collection, open for inspection—may be followed by location and scope; CI, maintains an institutional collection open for inspection, may be followed by location and scope; E, collection open for exchange; L, collection open for loan; B, maintains bibliography open for inspection—may be followed by scope; *, location of major collections in the field not maintained by members of the Academy. See Proceedings of the Indiana Academy of Science Vol. 61 for addresses of members. Inspection, exchange and loan of specimens and inspection of bibliographies are subject to reservations and conditions made by persons maintaining them. Institutions are indicated as follows: A.B.S.—American Bryological Soc. Herb.; A.M.N.H.—American Mus. Nat. Hist.; B.U.—Butler Univ.; B.S.T.C.—Ball State Teachers Col.; Buck. U.—Bucknell Univ.; C.N.H.M.—Chicago Nat. Hist. Mus.; C.U.—Cambridge Univ., England; D.U.—DePauw Univ.; E.C.—Earlham Col.; H.C.—Hanover Col.; H.U.—Harvard Univ.; I.D.C.—Ind. Dept. Cons., Dept. of Entomol.; I.N.H.S.—Ill. Nat. Hist. Surv. at Urbana; I.S.T.C.—Ind. State Teachers Col.; I.U.—Indiana Univ.; K.S.T.C.—Kas. State Teachers Col.; L. of O.—Lab. of Osteology, 707 Anita St., Bloomington, Ind.; M.B.G.—Mo. Bot. Gard.; M.N.H.—Mus. Nat. Hist., Paris, France; M.C.Z.—Mus. Comp. Zoology, Harvard Univ.; N.D.U.—Notre Dame Univ.; N.U.R.B.—Northern Utilization Res. Branch, U. S. Dept. Agr., Peoria, Ill.; N.V.H.S.—North Vernon High School; N.Y.B.G.—N. Y. Bot. Gard.; O.S.U.—Ohio State Univ.; P.U.—Purdue Univ.; P.U.A.E.S.—Purdue Univ. Agr. Exp. Sta.; R.U.—Rutgers Univ.; S.F.C.—St. Francis Col.; S.S.H.S.—South Side High School, Fort Wayne, Ind.; T.U.—Taylor Univ.; U.C.—Univ. of Cincinnati; U.K.—Univ. of Kas.; U.M.—Univ. of Mich.; U. of A.—Univ. of Alabama; U. of C.—Univ. of Calif., Citrus Exp. Sta.; U. of F.—Univ. of Fla.; U. of I.—Univ. of Ill.; U. of Ia.—Univ. of Iowa; U.S.D.A.—Nat. Mus., U. S. Dept. Agr.; U.S.N.M.—U. S. Nat. Mus.; V.U.—Valparaiso Univ.; W.C.—Wabash Col.; W. Va.—West Va. Univ.

BOTANY

Conservation

Smucker, Silas J. (Cultivated grasses, fungi; PE)

Cultivation

Starr, Richard C. (Algae; cf. Cytology and/or Genetics & Morphology; PE; CI, I.U., all algae that can be maintained in culture; E; * C.U. & M.N.H.)

Cytology and/or Genetics

Delisle, Albert L. (Aster; PP; PE; CI, N.D.U., fair; L; B, fair; * H.U.)

Farquharson, Lois I. (Maydeae, especially Tripsacum spp., cf. Morphology & Embryology)

Starr, Richard C. (Desmids; cf. Cultivation & Morphology)

Ecology

Markle, Carrolle A. (Angiosperms cf. Taxonomy and/or Distribution)
McCormick, Jack (Higher plants; cf. Taxonomy and/or Distribution; PP; PE; CI, B.U., R.U.; B, vegetational and general botany)
Overlease, William R. (General; cf. Taxonomy and/or Distribution & Natural Science)
Plummer, Gayther (Caesalpinoideae, ecological life histories and silviphotogrammetry)
Potzger, John E. (Forest studies; cf. Taxonomy & Paleontology; PP; PE)
Stearns, Forest (Genera with weedy habits chiefly Plantago, Cirsium, Ambrosia, Amaranthus, Setaria and Triticum; cf. Taxonomy and/or Distribution; CI, P.U.A.E.S., small; B)
Wagner, Kenneth A. (Liverworts; cf. Taxonomy and/or Distribution)
Weber, Robert C. (Pteridophytes; cf. Taxonomy and/or Distribution)
Westmeyer, Paul (Chiefly trees; PP; CI, N.V.H.S., few)

Embryology

Farquharson, Lois (Tripsacum; cf. Cytology and/or Genetics & Morphology)

Evolution

Canright, James E. (Magnoliaceae & Annonaceae; cf. Morphology & Paleontology)
Just, Theodor (Gymnosperms & Angiosperms; cf. Taxonomy and/or Distribution, Morphology, Paleontology)
Weatherwax, Paul (Gramineae; cf. Morphology)

Forestry

DenUyl, Daniel (Hardwoods and pines; PP; PE; B, biological aspects of Forestry)

Morphology

Canright, James E. (Magnoliaceae & Annonaceae; cf. Evolution & Paleontology)
Farquharson, Lois I. (Tripsacum; cf. Embryology & Cytology and/or Genetics; PP; CP, I.U., seeds and living plants)
Just, Theodor (Gymnosperms; cf. Taxonomy and/or Distribution, Evolution, Paleontology)
Starr, Richard C. (Soil algae; cf. Cultivation & Cytology and/or Genetics)
Weatherwax, Paul (Gramineae; cf. Evolution; PP; PE; CP; CI, I.U., herbarium and living plants; B, general agrostology; *all large herbaria)

Natural Science

Overlease, William R. (Popular approach, folk lore, uses, legends; cf. Taxonomy and/or Distribution & Ecology)

Pathology

Goss, Robert C. (General; CI, P.U.; L)

Physiology

Miller, Brinton M. (Mucorales, antibiotics of: CP: CI, P.U., viable cultures: E, limited: B, beginning: *N.U.R.B.; Am. Type Culture Col., Wash., D. C.; Centralpurean vor Schimmelcultures, Baarn, Netherlands)

Pittenger, R. C. (Actinomycetes, industrial fermentations; cf. Taxonomy and/or Distribution)

Taxonomy and/or Distribution

Biological Survey Committee of the Ind. Acad. Sci., Chairman (B, general, incomplete)

Brown, Lucy (Deciduous and evergreen trees of N. A.; CP—not open for inspection but L, R#1, Vevay, Ind., 200 specimens)

Buser, Franklin B. (Embryophyta, mostly Fountain County; PP; CP, 149A Stadium Terrace, Champaign, Ill., U.S.; E)

Cottingham, J. O. (Fleshy fungi; PP; PE; CP, D.U.)

Cummins, George B. (Uredinales; PP; PE; CI, P.U.A.E.S., world; E; L; B, world)

Daily, Fay Kenoyer (Characeae: PP: PE: CP, B.U., world E: L: B, Ind.—published; published Ind. algae—file at B.U., basis of check lists by C. M. Palmer, now maintained by C. M. Palmer, W. A. & F. K. Daily—address remarks to latter: * C.N.H.M. & U.S.N.M.)

Daily, William A. (Myxophyceae; PP; PE; CP, B.U., general; E; L; * C.N.H.M. & N.Y.B.G.)

Fisher, T. Richard (Heliopsis and Silphium; PP; PE; CP; L; B, Compositae—Taxonomy, Genetics, Cytology & Biosystematics)

Heiser, Charles B., Jr. (Helianthus; PP; PE; CP & CI, I.U., Deam and I.U. herbaria; E; L; B, Helianthus; * U. S. N. M., M.B.G., etc.)

Jones, G. N. (Flowering plants and bryophytes; PE; CI, curator of herbarium; E; L; B, all plants)

Just, Theodor (Cycadaceae & other gymnosperms, Chenopodiaceae; cf. Evolution, Morphology & Paleontology; PE; CI, C.N.H.M., large, curator of herbarium; E; L; B, broad; * other large museum collections here and abroad)

McClung, L. S. (Clostridium, anaerobic bacteria; PP; PE; CP, I.U., one of largest in world; E; B, all phases, 1200-1500 articles per yr.; *Amer. and Nat. Type Culture Collections)

McCormick, Jack (Higher plants; cf. Ecology)

Markle, Carrolle A. (Angiosperms; cf. Ecology; CI, E.C., large; E)

Martin, Sister M. Celine (Flowering plants & insects; cf. Zoology, Taxonomy and/or Distribution; CP, S.F.C., very limited)

Overlease, William R. (General; cf. Natural Science & Ecology; CP, Elkhart, Ind., 500 specimens from Ind., Mich., Cal.; B, small)

Palmer, C. M. (Lemanea & Sacheria; PP; PE; CP; B)

Pittenger, R. C. (Actinomycetes; cf. Physiology; PE; *N.U.R.B.)

Potzger, John E. (Grasses; cf. Ecology & Paleontology; PP; PE; CP, B.U.; L; *B.U., N.D.U., U.S.N.M.)

Rector, Marion A. (Mrs. Ralph E.) (Pteridophyta; PP; CP, 500 sp., Delaware and surrounding counties; CI, extensive)

Sperry, Theodore M. (Vascular plants; CI, K.S.T.C., 200+ specimens; E; L)

State Flora Committee, Ind. Acad. Sci., Chairman (Flowering plants—to supplement *Deam's Flora;* PP; CI—see published records; B, B.U.)

Stearns, Forest (Plantago, Cirsium, Ambrosia, Amaranthus, Setaria & Triticum; cf. Ecology)

Tryon, Rolla Milton, Jr. (Ferns; PP; PE; CI, M.B.G., world; L)

Wagner, Kenneth A. (Liverworts; cf. Ecology; PP; PE; CI, D.U.: E?; L?; *A.B.S.)

Ward, Daniel B. (Sisyrinchium; CI, W.C.; L)

Weber, Robert C. (Pteridophytes; cf. Ecology; C.P., partly CI, S.S.H.S., incomplete, general; L; possibly; * U.M.)

Welch, Winona H. (Fontinalaceae & Hookeriaceae; PP; PE; CP; CI, D.U., world; E; L; B, Ind.; * D.U., I.U., U. of I., C.N.H.M., larger herbaria throughout world)

Yuncker, T. G. (Cuscuta; PP; PE; CP, CI, D.U., world; E, limited; L, limited; B, world; * Any large herbarium)

ARCHAEOZOOLOGY

Adams, William R. (Vertebrates—osteological specimens particularly from archaeological sources; PP; PE; CP, L. of O., U.S. osteology; E; L; *Chicago, H.U., Wash.)

PALEONTOLOGY

Bieber, C. L. (Cephalopods, stratigraphy; PP; CI, Greencastle, Ind.; E; L; B, limited; * I.U., U.S.N.M.)

Campbell, Guy (Devonian-Mississippian, invertebrates & plants, stratigraphic distribution; PE; CP, Corydon, Ind.; E; L?; CI, H.C., Curator Geol. Mus., Paleozoic; E; B, Dev.-Miss.)

Canright, James E. (Pennsylvanian Age flora—taxonomy, anatomy, distribution—both geographic and stratigraphic; cf. Botany—Evolution & Morphology; PP; PE; CI, I.U.; B, carbon floras, stratigraphy)

Cross, Aureal T. (Paleozoic plants—morphology, taxonomy, stratigraphy; coal—origin, constitution, stratigraphy; PP: PE: CP: CI, W. Va. Geol. Sur. and Univ., general coal types of W. Va., gen. Paleozoic plants, gen. invertebrates of coal bearing rock: E: L:, possibly: * U.S.N.M.)

Guennel, G. K. (Spores of Pteridophytes & Gymnosperms in coal—their distribution, taxonomy, morphology; PP: PE: CP: CI, Coal Sec., Ind. Geol. Sur., I.U.: E: L, probably: B, complete spore Bibliog.: *Urbana, Ill.; Ann Arbor, Mich.; Columbus, O.)

Guernsey, E. Y. (Fossils in general; CP—on loan to County Museum, Bedford, Ind.)

Hoskins, John H. (Lower Mississippian and Devonian, vascular plants: coal ball floras—morphology and taxonomy: PP: PE: CP: CI, U.C.: L, some: *Wash., D.C.; St. Louis; U. of I.)

Just, Theodor (Cycadaceae, and other fossil gymnosperms; cf. Botany—Taxonomy and/or Distribution, Evolution, Morphology; PE; CI, curator at C.N.H.M., large; B, large; *other large museums here and abroad)

Marshall, G. Edward (Fossils of St. Louis and St. Genevieve limestone—distribution and taxonomy; cf. Control; CP, Orleans, Ind., fossils of St. Louis limestone; E)

Potzger, John E. (Pollen analysis; cf. Botany—Taxonomy and/or Distribution & Ecology; PP; PE; B)

Wayne, William J. (Pleistocene land and fresh water gastropods—interglacial and interstadial migrations and extinctions of faunal elements; CP, Geol. Sur., I.U., small; B, partially complete; * U.M., U.K., O.S.U.)

ZOOLOGY

ANATOMY

Rifenburgh, S. A. (Vertebrates; cf. Genetics; PP; PE; B, limited)

BIOLOGY

Goodnight, Clarence J. (Arachnids—Opiliones; cf. Taxonomy and/or Distribution)

Montgomery, B. Elwood (Odonata, bumblebees—pollinating activities; cf. Taxonomy and/or Distribution; CI, bees, P.U.; E; L)

COMMERCIAL

Windsor, Alton S., Sr. (Commercial biology; PE; CI, Rt. 3, Bloomington, Ind.; L)

CONSERVATION

Allyn, William P. (Reptiles & salamanders—amphibians; cf. Taxonomy and/or Distribution; PP; CP; B, not too complete; I.S.T.C.)

Barnes, William B. (Game birds and mammals; cf. Taxonomy and/or Distribution; PE; B, limited)

CONTROL

Deay, Howard O. (Homoptera, Hemiptera—reactions to electromagnetic waves and ultrasonics; cf. Taxonomy and/or Distribution)

Marshall, G. Edward (Insects of apples, peaches, grapes, strawberries; cf. Paleobotany; PP; PE)

Mizelle, John D. (Trematodes, Nematodes, Cestodes; cf. Taxonomy and/or Distribution, Morphology, Life History)

Schuder, Donald L. (Coccoidea—scale insects; cf. Taxonomy and/or Distribution)

ECOLOGY

Daggy, Tom (Coleoptera—largely immature forms; cf. Taxonomy and/or Distribution)

Drummond, Roger O. (Mites; cf. Taxonomy and/or Distribution)

Eberly, William R. (Isopods—terrestrial, crayfish; cf. Taxonomy and/or Distribution; PP; PE; CP, I.U., limited; E; L; B, of state, extensive; *Isopods—A.M.N.H., crayfish—U.S.N.M.)

Garner, Murvel R. (Soil earthworms—effect on soil; cf. Taxonomy and/or Distribution; PE; B)

Krekeler, Carl (Cave Carabidae—Coleoptera; cf. Taxonomy and/or Distribution)

Lewis, Robert Earl (Insects and mammals; cf. Taxonomy and/or Distribution)

Mumford, Russell E. (Birds & mammals—bats; cf. Taxonomy and/or Distribution & Life History)

Tasker, Roy C. (Amphibia & fishes—salamanders; cf. Life History & Histology)

Williams, Eliot C. (Symphyla; cf. Taxonomy and/or Distribution)

Young, Frank N. (Dystiscidae; cf. Taxonomy and/or Distribution)

EVOLUTION

Sonneborn, T. M. (Paramecium; cf. Taxonomy and/or Distribution & Genetics)

GENETICS

Ford, Lee (Collie dogs—cytogenetics, breeding; PE; CP, Butler, Ind.)

Rifenburgh, S. A. (Vertebrates; cf. Anatomy)

Sonneborn, T. M. (Paramecium; cf. Taxonomy and/or Distribution & Evolution)

HISTOLOGY

Tasker, Roy C. (Amphibia and fishes—salamanders; cf. Life History & Ecology)

LIFE HISTORY

Cable, R. M. (Trematoda and their larvae; cf. Taxonomy and/or Distribution)

Mizelle, John D. (Trematodes, Nematodes, Cestodes; cf. Taxonomy and/or Distribution, Morphology, Control)

Mumford, Russell E. (Birds & mammals—bats; cf. Taxonomy and/or Distribution; Ecology)

Tasker, Roy C. (Amphibia & fishes—salamanders; cf. Ecology & Histology; CP, Buck. U., small; E; L; B)

Ward, Gertrude L. (Spiders, reptiles, snails & clams; cf. Taxonomy and/or Distribution)

MORPHOLOGY

Mizelle, John D. (Trematodes, Nematodes, Cestodes; cf. Taxonomy and/or Distribution, Life History & Control)

NATURAL HISTORY

Cooper, Robert H. (Locustidae—Serpentes; cf. Taxonomy and/or Distribution)

Minton, Sherman A., Jr. (Reptiles and Amphibians; cf. Taxonomy and/or Distribution)

PARASITOLOGY

Feldman, Harrison Lee (Helminths, Protozoa—drug screening & cultivation of several protozoa)

TAXONOMY AND/OR DISTRIBUTION

Allyn, William P. (Reptiles & salamanders—amphibians; cf. Conservation)

Ash, Charles R. (Insecta—Tingoidea—Hemiptera; PP in press; CP, U. of C., limited; E; L; B, limited; * Dr. Carl J. Drake, formerly of U. of Ia.)

Barnes, William B. (Game birds and mammals; cf. Conservation)

Barrett, John P. (Indiana Diptera only)

Bell, Robert L. (Microsporidian; CP, home address, microscope slides; L)

Biological Survey Committee of the Ind. Acad. Sci., Chairman (General; B, incomplete)

Bushey, Clinton J. (Land gastropoda; PE; CP; CI, T.U., local; E; L; B, incomplete; * U.S.N.M., U.M.)

Cable, R. M. (Trematoda and larvae; cf. Life History; PP; PE; CP, P.U.—not open for inspection but E & L, limited; B, incomplete; *U.S.N.M.)

Cooper, Robert H. (Locustidae—Serpentes; cf. Natural History PP; PE; CP & CI, B.S.T.C., broad; * U.S.D.A.)

Cope, James B. (Bats, Chickadees; PE; CI; E.C., large; E; L; B, as complete as possible; * C.N.H.M.)

Daggy, Tom (Coleoptera—largely immature forms; cf. Ecology; PP; PE; CP; Davidson, N.C.; 20,000 beetles; E; L)

Deay, Howard O. (Homoptera—Hemiptera; cf. Control; PP; PE; CI, P.U., Corixidae, Cicadellidae, Coreidae; L?; B, insects and partly complete for other families; * U.S.N.M., I.N.H.S., U.K.)

Downie, N. M. (Coleoptera; CP, home address, 20,000+ specimens from U.S.A.; E; L; B, limited; *P.U.)

Drummond, Roger O. (Mites, tree hole fauna at Shades St. Pk.; cf. Ecology; CP, with Dr. E. C. Williams, W.C.)

Eberly, William R. (Isopods—terrestrial, crayfish; cf. Ecology)

Garner, Murvel R. (Soil earthworms; cf. Ecology)

Gerking, Shelby D. (Fishes; PP; PE; CI, I.U., all species of state; E; L; B, Indiana fishes; *all large museums of country)

Goodnight, Clarence J. (Arachnids—Opiliones; cf. Biology; PP; PE; CI, A.M.N.H., world; E; L; B, inclusive; * M.C.Z.)

Krekeler, Carl H. (Cave Carabidae—Coleoptera; cf. Ecology; CP, Valparaiso; E; L; B; *U.S.N.M., U. of A.)

Lewis, Robert Earl (Insects and mammals; cf. Ecology; CP; CI, E.C., mammals; L; B, zoology)

Macklin, Jerry M. (Arthropods—Hexaptera)

Martin, Sister M. Celine (Flowering plants and insects; cf. Botany, Taxonomy and/or Distribution)

Minton, Sherman A., Jr. (Mostly N.A. reptiles & amphibians; cf. Natural History; PP; PE; CP, reptiles and amphibians; E, limited; L; B, midwest herpetology; *U.M., C.N.H.M., U. of I. Nat. Hist. Mus., Chi. Acad. Sci.)

Mizelle, John D. (Trematodes, Nematodes, Cestodes; cf. Morphology, Life History, Control; PP; PE; CP, N.D.U., monogenetic trematodes; E; L; B, parasitology; * U.S.N.M.)

Mockford, Edward L. (Psocids—insects; PP; PE; CP, U. of F. temporarily, world; E; L; B, Psocids; * U.S.N.M., I.N.H.S.)

Montgomery, B. Elwood (Odonata; cf. Biology; PP; PE; CP, home address, world; E; L; B, complete for world Odonata with specific and generic index; * U.M.—E. B. Williamson col.)

Mumford, Russell E. (Birds & mammals—bats; cf. Ecology & Life History; PE; CP; CI, P.U., E.C., U.S.N.M.; E; L; B, as complete as possible; * U.S.N.M., P.U., C.N.H.M., E.C.)

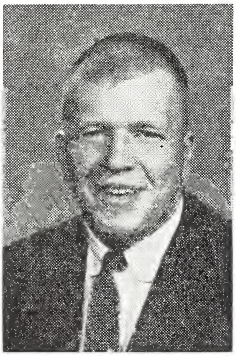
Schuder, Donald L. (Coccoidea—scale insects; cf. Control; PP; PE; CI, P.U.; E; B, Coccoidea; * I.D.C.)

Sonneborn, T. M. (Ciliata—Paramecium; cf. Evolution, Genetics: PE: CP, I.U., world—living cultures of Paramecium: E: *Edinburgh, Scotland; Miami, Fla.; Los Angeles, Cal.; Philadelphia, Pa.; Oak Ridge, Tenn.

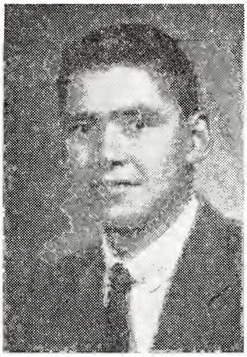
Ward, Gertrude L. (Spiders, reptiles, snails & clams; cf. Life History; PP; CP; CI, E.C.; E; L; B, limited; * C.N.H.M., A.M.N.H.)

Williams, Eliot C., Jr. (Symphyla; cf. Ecology; CP, W.C., world; E; L; B, as complete as possible)

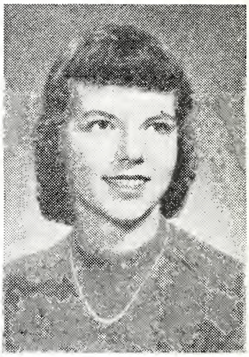
Young, Frank N. (Dystiscidae; cf. Ecology; PP; PE; CP; CI, I.U., general; E; L; *U.M.)



Leroy Kinsey
Vice-President
Howe High School



James Dincolo
President
Adams High School



Janet Golba
Secretary
Adams High School

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1954

President: James Dincolo, Adams Walton Club, John Adams H. S., South Bend.

Vice-President: Larry Kinsey, Science Club, Howe H. S., Indianapolis.

Secretary: Janet Golba, Adams Walton Club, John Adams H. S., South Bend.

Members of the Council: Harold Stewart, Bloomington (1950-1954); Arthur L. Smith, South Bend (1951-1955); Charles E. Karst, Mishawaka (1952-1956); Edith Wallace, Gary (1953-1957); Jerry Motley, Indianapolis (1954-1958).

PROGRAM OF THE TWENTY-SECOND ANNUAL MEETING

Joint Meeting With the Purdue Sci-Math Assembly
October 16, 1954
Memorial Union Building
Purdue University, Lafayette, Indiana

8:30-10:00 a. m. Registration and Placement of Exhibits, South Ballroom, Memorial Union Building.

10:00 a. m. Career Conferences for High School Students. Science consultants available from biology, chemistry, mathematics, physics, agriculture, engineering, home economics and pharmacy of the Purdue University staff.

10:30 a. m. Project Clinic. Room 231. Opportunity for students to receive help from scientists on special projects.

11:00 a. m. Junior Academy of Science Business Meeting. Room 350, Memorial Union Building.

10:00 a. m.-12:00 a. m. Visits to Campus Laboratories and Shops.

1:30 p. m. The Assembly Program

Biological Sciences Section, James Dincolo, presiding.

1. A Diet Study of the Long-Eared Owl. Geoff Baker, New Castle High School, New Castle.
2. Breeding Bird Population Study. Lewis Nading, Shortridge High School, Indianapolis.
3. Biography of a Royal Moth. Joan Compton, Elkhart High School, Elkhart.
4. The Effect of Hormones on Root Production in Geranium Cuttings. Barbara Webster, Howe High School, Indianapolis.
5. Poisonous Snakes of Indiana. Bill Mitchell, Lew Wallace High School, Gary.
6. Preparing Mounted Skeletons. Jane Vogt and Luanne Schneider, Howe High School, Indianapolis.
7. Artificial Parthenogenesis of the Bull Frog. Nancy MacIvor, Adams High School, South Bend.
8. Medical Mycology. Robert Little, Howe High School, Indianapolis.
9. "The Acres," A Conservation Project. Raymond Kern, Central High School, Fort Wayne.
10. Urinalysis. Fred Green, Howe High School, Indianapolis.
11. A Comparison of Waters and Water Life of Southeast Ontario and Southern Indiana. John Clayton, University High School, Bloomington.

Mathematics Section, Allen Waltz, Linden High School, presiding.

1. Number Systems Other Than the Decimal System. Nancy Coleman, Bosse High School, Evansville.
2. Magic Squares and How to Make Them. Jerry Smith, Eastern School, Greentown.
3. Some Unusual Problems in Geometry. Larry Maxey, Duane Barts and James Rannie, Elston High School, Michigan City.

4. Primitive Pythagorean Triplets. Gary Gilmore, Griffin High School, Griffin.
5. Some Topological Twists. Tom White, Arsenal Technical High School, Indianapolis.
6. The Four-Dimensional Earth. Stanley Kaminski, Hammond High School, Hammond.
7. Curves Traced by a Compound Pendulum. Alex Alexandrow, Central High School, Fort Wayne.
8. The Binary Number System. Lisa Barrett, Hammond High School, Hammond.

Physical Sciences Section, Larry Kinsey, presiding.

1. Secondary School Program at the Roscoe B. Jackson Memorial Laboratory. Edward Lollis, Howe High School, Indianapolis.
2. Proposed Experiments with a Cathode Ray Tube. Thor Semler, New Castle High School, New Castle.
3. Effects of Heat on Strength and Microstructure of Steel. David Rasmussen, Howe High School, Indianapolis.
4. Twin-Elliptic Pendulum. Alex Alexandrow, Central High School, Fort Wayne.
5. Conquest of Space. Larry Rothrock, Bloomington High School, Bloomington.
6. Principle and Construction of a Van de Graff Generator. Robert Fassnacht, Central High School, South Bend.
7. Meteorology and Weather. Robert Shomo, Mishawaka High School, Mishawaka.
8. The Future Development of Science. William Rand, Chesterton High School, Chesterton.
9. The Solar Eclipse of June 30, 1954. Roger Cuffey, University High School, Bloomington.

MINUTES

The twenty-second annual meeting of the Indiana Junior Academy of Science was held as a combined session with the Purdue Sci-Math Assembly Saturday, October 16, 1954. Approximately 1,600 students, teachers and friends attended the day's science program in the Memorial Union Building of Purdue University.

A large collection of science projects and exhibits by high school students was displayed in the south ballroom of the Memorial Union Building.

At 10:00 a. m. Dean W. L. Ayres of the Purdue University School of Science, Education and Humanities addressed the students briefly in the exhibit hall. Dean Ayres encouraged students to continue their interest in science and mentioned some of the possibilities for scientific careers.

Following the talk students were given the opportunity to visit with specialists of the Purdue staff in various mathematics and science fields. Students were encouraged to ask questions and gain further information on careers in science.

The project clinic was another feature of the morning activities. High school students and sponsors were given an opportunity to discuss present and proposed science projects with university staff members.

Instructional and research laboratories of the University were open to visiting teachers and students from 10:00 a. m. to 12:00 noon. Members of the various departments were on hand to answer questions and explain procedures.

The annual business meeting of the Junior Academy of Science was held at 11:00 a. m. with President James Dincolo presiding.

Mr. Harold A. Stewart, chairman of the Junior Academy Council, announced that Robert Fassnacht, Central High School, South Bend, was named "best boy," and Nancy MacIvor, John Adams High School, South Bend, was chosen as "best girl" in science for 1954. The winners of these awards are selected on the basis of information submitted each year by sponsors of the Junior Academy clubs. Each of the students is given a year's membership in the American Association for the Advancement of Science.

The following officers were elected for the year 1955. President, Bob Conway, Science Club, Shortridge High School, Indianapolis; Vice-President, Paul Justus, Phy-Chem Club, Elmhurst High School, Fort Wayne; Secretary, Luanne Schneider, Science Club, Howe High School, Indianapolis.

Mr. Howard H. Michaud, State Sponsor, Purdue University, reported the selection of Mr. Jack Munsee, Science Club Sponsor, University High School, Bloomington, as a member of the Junior Academy Council. Mr. Munsee will replace Mr. Harold A. Stewart, Bloomington High School, whose term expired in 1954.

Mr. Michaud also mentioned briefly the splendid progress that has been made by the Junior Academy during the past year. Six new science clubs were added to the Junior Academy in 1954 as follows: Science Club, Chesterton High School, Chesterton, Mr. Robert McCord, Sponsor; The Alchemists, Edinburg High School, Edinburg, Mr. S. C. Harrell, Sponsor; Science Club, Hamlet High School, Hamlet, Mr. Lawrence Cushman, Sponsor; Phi-Chi Club, New Haven High School, New Haven, Mr. Keith Hunnings, Sponsor; Science Club, Rossville High School, Rossville, Mr. Martin Silverthorn, Sponsor; and the Up and Atom Club, Sandborn High School, Sandborn, Mr. Paul D. Carter, Sponsor.

There are approximately fifty high school science clubs enrolled in the Junior Academy and it is hoped that at least ten new clubs will be added in 1955.

The business session was adjourned at 12:00 noon.

The afternoon assembly program, starting at 1:30 p. m., was divided into three sections including biological sciences, mathematics and the physical sciences. The biological sciences section met in Room 350 of the Purdue Memorial Union building. James Dincolo, president of the Junior Academy, presided. Allen Waltz, Linden High School, served as chairman of the mathematics section in Room 363 and Larry Kinsey, Vice-President of the Junior Academy, conducted the physical sciences section in Room 340. A total of twenty-seven papers were read in three sections.

The joint meeting of the Junior Academy and the Purdue Sci-Math Assembly was the most extensive program ever offered to high school science clubs in Indiana. The large attendance proved that there is a growing interest in science.

The Junior Academy will hold its twenty-third annual meeting at Notre Dame University, October 15, 1955. Plans will be undertaken immediately to provide another worth-while program. High school science clubs and sponsors are urged to cooperate and participate by preparing papers and exhibits for the annual session.

INDIANA JUNIOR ACADEMY OF SCIENCE CLUBS

Fall 1954

Town	*School and Club*	*Sponsor*
1. Attica	H. S., Sci-Math (1949)	J. Claude Daugherty
2. Bedford	H. S., Science (1951)	Elmer Wright
3. Bloomington	H. S., National Scientific Honor Society (1931)	Harold A. Stewart
4. Bloomington	University H. S., Jr. Academy (1938)	Jack Munsee
5. Chesterton	H. S., Science (1954)	Robert McCord
6. Clayton	H. S., Jr. Academy (1951)	Howard C. Lewis
7. Crawfordsville	H. S., Up-N-Atom (1950)	David Wells
8. Edinburg	H. S., The Alchemists (1954)	S. C. Harrell
9. Elkhart	H. S., Jr. Academy (1940)	Mrs. Evelyn Waggoner Miller
10. Fort Wayne	Central H. S., Biology (1940)	Iva Spangler
11. Fort Wayne	Central Catholic H. S., Albertus Magnus Science Club (1952)	Sister Mary Agnita S.P.
12. Fort Wayne	Elmhurst H. S., Phy-Chem (1935)	Ruth Wimmer
13. Fort Wayne	North Side H. S., Nature (1936)	Vesta Thompson
14. Gary	Calumet Twp. H. S., Science (1952)	Mrs. Catherine Dale
15. Gary	Edison H. S., Beaker Breakers (1949)	Mrs. Martha B. Connor
16. Gary	Lew Wallace H. S., Biology (1935)	Lola Lemon
17. Gary	Lew Wallace H. S., Klub Kem (1941)	Mrs. Helen McKenzie
18. Gary	Tolleston H. S., Biology (1952)	Edith Wallace

	Town	*School and Club*	*Sponsor*
19.	Gary	Tolleston H. S., Future Scientists of America (1949)	Arthur Kline
20.	Gary	Wirt H. S., Biology (1945)	Mrs. Frances Huddleston
21.	Gas City	Mississinewa Joint H. S., Science (1936)	Roy McKee
22.	Griffith	H. S., Science (1953)	George M. Bunce
23.	Hamlet	H. S., Science (1954)	Lawrence Cushman
24.	Hammond	Morton Jr. H. S., Science (1949)	Nancy Lou Ritter
25.	Hobart	H. S., Science (1952)	Lola Stewart
26.	Indianapolis	Shortridge H. S. Naturalist's Club (1947)	Max Forsyth
27.	Indianapolis	Shortridge H. S., Science (1931)	Mrs. Henrietta A. Parker
28.	Indianapolis	Technical H. S., Nature (1932)	Howard L. Cook
29.	Indianapolis	Howe H. S., Science (1949)	Jerry Motley
30.	Indianapolis	Washington H. S., Science (1931)	Estil Van Dorn
31.	Lebanon	H. S., Jr. Explorers of Science (1953)	Helen E. Reed
32.	Marion	Martin Boots Jr. H. S., Biology (1953)	John Clevenger
33.	Mishawaka	H. S., Science (1936)	Darl F. Wood
34.	New Albany	H. S., Science (1935)	L. S. Rose
35.	New Castle	H. S., Science (1947)	Mary Rankin
36.	New Haven	H. S., Phi-Chi (1954)	Keith Hunnings
37.	Richmond	H. S., Science (1950)	Kathryn Coulter
38.	Rossville	H. S., Science (1954)	Martin Silverthorn
39.	Sandborn	H. S., Up and Atom (1954)	Paul D. Carter
40.	South Bend	Central H. S., Jr. Izaak Walton (1939)	A. L. Smith
41.	South Bend	John Adams H. S., Adams Walton (1953)	Ernest Litweiler
42.	Sullivan	H. S., Camera (1939)	Ruth Hinkle
43.	Terre Haute	State H. S., Senior Science (1939)	Russell McDougal
44.	Valparaiso	H. S., Science (1931)	Gerald Doeden

NECROLOGY

Will E. Edington, DePauw University

Harry Frederic Dietz

Indianapolis, Indiana	Chadds Ford, Pennsylvania
December 8, 1890	September 4, 1954

In this day of high scientific specialization it is refreshing to know that there are still a few scholars and a few naturalists. Indiana has been fortunate in being at one time the home of some of America's great naturalists. Thomas Say, who came to Indiana in 1826 as a part of the New Harmony experiment and spent the remainder of his life in Indiana, was an all around naturalist who became known as the "Father of American Entomology." Probably two of the best known Indiana naturalists were David Starr Jordan and Willis S. Blatchley, both very prominent in the first quarter of this century. But the rugged competition and high specialization required today for scientific leadership leaves few men with the energy and time to achieve distinction as naturalists or scholars. However, Harry Frederic Dietz was no ordinary scientist, for he was an avid student of nature. Recognized nationally as an entomologist, he also had a wide knowledge of plant pathology, plant ecology and plant culture. "He loved, appreciated, and understood nature as an entity and not as a series of compartmented specialties."

Harry F. Dietz was born in Indianapolis on December 8, 1890, and spent his boyhood and early manhood there. Following his graduation from Shortridge High School he became an assistant, in 1909, in the office of the Indiana State Entomologist. He also entered Butler University and five years later received the Bachelor of Arts degree. During this period, however, he was for a time a student assistant in entomology at the Montana Experiment Station at Bozeman, Montana. From 1914 to 1916 he was Indiana Deputy State Entomologist and during these two years he collaborated with Harold Morrison, then in the State Entomologist's office, in a study that later led to the publication of an outstanding joint taxonomic paper on "The Coccidae of Indiana." Then followed four years of service as an entomological inspector in the Federal Horticultural Board and Bureau of Entomology in the U. S. Department of Agriculture with headquarters in Washington, D. C. In 1920 he returned to Indiana as Assistant State Entomologist in the State Department of Conservation.

He had joined the Indiana Academy of Science in 1909, at the age of nineteen, and having become a member of the American Association for the Advancement of Science in 1917 and a Fellow three years later, on his return to Indiana he entered enthusiastically in the work of the Academy. He was interested in getting an Index for the Proceedings and he and John S. Wright were appointed in 1921 as a committee to consider the problem. In 1922 he was made a Fellow of the Academy and the following year was elected Press Secretary and served for the next six years. From 1924 to 1929 he was chairman of the Academy Committee on Biological Survey and a member of the Committee on the State Library. He presented three papers on the termites of Indiana, two of which were published in the Proceedings for 1920 and 1923.

Feeling the need of further scientific training he resigned in 1929 as Assistant State Entomologist and began graduate study at the Ohio Experiment Station of Ohio State University at Wooster, Ohio, as a Crop Protection Institute Fellow in entomology and received the Master of Arts degree in 1930. The following year he was a Grasselli Fellow in entomology and the Ph.D. degree was conferred on him in 1931. He remained at the Ohio Experiment Station and in 1932 was made a research entomologist of the Grasselli Chemical Company, a subsidiary of the E. I. du Pont de Nemours and Company, and carried on insecticide investigations in cooperation with the Ohio Experiment Station until 1936, when he went to Wilmington, Delaware, to work on pest control research in the Du Pont Experimental Station. He became a group leader in 1948 and was promoted to manager of the Agricultural Chemicals Section in 1949, which position he held until his sudden death from heart attack on September 4, 1954.

Dr. Dietz possessed seemingly boundless energy and his brilliant and inquiring mind coupled with a fine personality enabled him to work effectively with others in research. His extensive knowledge of field conditions and the life history of injurious insects and plant diseases was of utmost importance in the development of new agricultural chemicals, and among the many new pest control products that he helped to establish are "Copper A, dithiocarbamates, 'Lorol,' DDT, methoxychlor, BHC, 'Ammate,' and 2,4-D."

Among his many publications on entomology were studies on scale insects and termites of Indiana; termites of Panama and the Canal Zone; blackfly of citrus; insects and diseases of greenhouse and ornamental plants; and apple, peach and vegetable insects.

In addition to societies already mentioned, Dr. Dietz was a Fellow of the Ohio Academy of Science and a member of the Entomological Society, Sigma Xi, Gamma Sigma Delta honor agricultural society, and Phi Delta Theta social fraternity.

Dr. Dietz had a deep interest in nature and he pursued horticulture as a hobby. He was especially interested in growing iris, peonies, lilies and azaleas, and he was an authority on the growing of a number of ornamentals. At one time he was much interested in rose culture.

Harry Dietz lived a full and effective life and he rendered genuine service to science and to humanity.

KARL BOYER MCEACHRON

Hoosick Falls, New York	Pittsfield, Massachusetts
November 17, 1889	June 24, 1954

Some thirty years ago on the north campus of Purdue University one saw a row of seventy-foot steel towers from which hung nests of insulators on which were strung metal cables whose distance apart could be varied from eighteen feet to thirty-eight feet. By means of large condensers and the use of all the power available on the campus a current of some thousands of amperes with a voltage as high as 600 kilovolts could be sent through these cables which then became surrounded throughout their full length by electrical discharges known as corona, and the Electrical Experiment Station was studying the losses through this corona on high voltage transmission lines and determining the reliability of insulator nests. Annually the Experiment Station held "Open House" and one of the spectacular displays was lightning discharges whereby blocks of wood were shattered and the surrounding air made pungent with ozone created by the ionization of the air by the electrical discharges. These studies had begun in a more modest way several years earlier and had led to some valuable results in obtaining nitrogen from the atmosphere and new methods of extracting ozone for commercial purposes. These earlier researches were under the direction of C. Francis Harding, Head of the School of Electrical Engineering, and were carried out by Karl Boyer McEachron whose outstanding success led to his appointment in 1922 as a research engineer by General Electric Company, with laboratories at Pittsfield, Massachusetts.

Dr. McEachron had come to Purdue in 1918 as an assistant engineer in the Electrical Engineering Experiment Station and two years later he was promoted to Research Associate. During this time he earned the Master of Science degree in Electrical Engineering at Purdue. A graduate of Ohio Northern University in 1912 with a degree in electrical engineering, he continued his study there for another year and received the Master of Engineering degree. The following year he spent with the General Electric Company as a student engineer on a test course. Completing his training in this test course, he returned to Ohio Northern, in 1914, as an instructor in electrical engineering and remained there until he received his appointment to Purdue in 1918. In 1922 he returned to the General Electric Company to take charge of the research and development section of Lightning Arrester Engineering Development at Pittsfield, Mass. At this time F. W. Peek, Jr., was carrying out his spectacular high voltage researches at Pittsfield and he had succeeded in building up a controlled voltage of 2,000,000 volts, at that time, 1923, the highest controlled voltage ever worked with in electrical engineering. During the next ten years Dr. McEachron did much pioneering in lightning and high voltage engineering and in 1933 he was appointed engineer in charge of the High Voltage Engineering Laboratory. In 1940 he was also appointed designing engineer of the Power Transformer Division. He became assistant works engineer in 1945 and he was named assistant manager of engineering, Transformer and Allied Products Divisions, in 1947 and manager two years later. He received the appointment of manager of the Laboratory-Engineering Department in 1952 and the following year was appointed consultant — professional employee relations — technical, Engineering Services Division, which position he held at the time of his death on June 24, 1954. He had been in poor health for some time but he was hospitalized only six days before his death. He was born in Hoosick Falls, New York, on November 17, 1889.

During these thirty-two years at Pittsfield he had become an international authority on lightning and high voltage engineering. Under his direction was built a 10,000,000 volt artificial lightning generator, duplicates of which were used in creating crashing lightning bolts at the New York World's Fair. In 1950 new developments led to the construction of a new High Voltage Laboratory with a generator capable of producing 15,000,000 volts and giving a lightning flash over a fifty-foot gap. He also originated and supervised a program that photographed and measured the strength of natural lightning bolts that struck the Empire State Building in New York City.

As one would expect, Dr. McEachron received many honors. In 1931 he was presented the Charles A. Coffin Award for his development of thyrite. The Edward Longstreth Medal of the Franklin Institute was given to him in 1935, and in 1949 he received the Edison Medal presented by the American Institute of Electrical Engineers. In 1952 he was honored with eminent membership in Eta Kappa Nu, national electrical engineering society, and the New England Award of the Engineering Societies of New England. He received his last honor in the summer of 1953 when he was elected an honorary member of the Societe Francaise des Electricians. Only a very few Americans have received this distinction. His Alma Mater, Ohio Northern, conferred the degree of Doctor of Engineering on him in 1938, and in 1948 Purdue University awarded him the honorary degree of Doctor of Science. He was listed in Who's Who in America and in American Men of Science.

As an expert on lightning he testified frequently before juries and Government committees on high voltage and lightning phenomena. He was the author of numerous scientific papers and he was co-author with K. G. Patrick of a book, Playing With Lightning, published in 1940. He also wrote "Lightning and Lightning Protection" for the Encyclopedia Britannica.

Dr. McEachron was a Fellow of the American Institute of Electrical Engineers, served on several of its committees, was a director from 1936 to 1940, and its vice-president from 1942 to 1944. He joined the Indiana Academy of Science in 1921, and was joint author of a paper that appeared in the Proceedings for 1921. He was a charter member of the Board of Registration of Professional Engineers for Massachusetts and served on this Board for ten years. He was a member of a Panel of the National Research and Development Board, Washington, D. C., from 1947 to 1949, and he also served on a subcommittee of the National Advisory Committee on Aeronautics from 1937 to 1946. During World War II he was chairman of an advisory committee on protection against lightning and static to the office of the Chief of Ordnance.

He made frequent trips around the country for the General Electric Company and fulfilled many speaking engagements in various cities. He was active in civic affairs in Pittsfield, having served as chairman of the Parking Meter Commission, a director of the Chamber of Commerce, and a member of the Tax Reform Association. He was also a member and a director of Rotary in Pittsfield. Active in the Methodist Church, he taught a Men's Bible Class for seven years and a Married Couples' Class for nine years. Woodworking was his special hobby and he was a skilled amateur photographer, being much interested in motion pictures.

It is noteworthy that Dr. McEachron retained an abiding interest in Purdue University and the Indiana Academy of Science. His three sons became Purdue graduates and he maintained his membership in the Academy throughout the years after he left the State. His distinguished career has brought honor both to Purdue and the Academy.

FREDERICK LEVERNE SERVISS

Telluride, Colorado	West Lafayette, Indiana
July 30, 1895	July 22, 1954

At one time, before the State became so highly industrialized, Indiana's limestone industry played a very important role in the State's economy, and one of the problems confronting that industry was the staining of the stone by the cement and mortar used in building construction. Naturally the industry turned to the scientists at Purdue for help and one of the toughest problems that long baffled the old School of Chemical Engineering at Purdue was to determine just what caused the staining and how it could be prevented. Professor Harry C. Peffer, for many years Head of the School of Chemical Engineering, spent many hours experimenting with and testing various cements and mortars to which various ingredients had been added in the hope that the straining might be prevented without effecting the binding qualities of the cement. But it remained for Professor Frederick L. Serviss, who came to Purdue in the Fall of 1929, to solve the problem.

Professor Serviss was primarily a geologist. He was born in Telluride, Colorado, on July 30, 1895, in a region in the San Juan Mountains noted for its mining, and following the completion of his public school education he entered the Colorado School of Mines. He was a Fellow in Civil Engineering in his Senior year and received the degree of Engineer of Mines in 1920. Two years later he received the M.S. degree in geology. His first position was with the American Metals Company and a little later he worked for the Tonopah Placer Mining Company. Also for a time he was assistant city engineer in charge of waterworks and construction for the city of Trinidad, Colorado. He began doing consulting work in 1922 and continued this kind of work for the rest of his life. He was a consulting engineer for the Colorado Fuel and Iron Company, the Union Pacific Coal Company, and for many years after 1922, for the Utah Fuel Company.

In 1923 he left Colorado and went to Washington, D. C., as a part-time instructor in geology at the Catholic University of America. He remained in Washington six years and during this time, in addition to his teaching, he did some graduate study in science and economics at George Washington University. In 1925 he also became a consultant for Ruebsam and Stevens, of Washington, continuing this work until 1931.

Professor Serviss accepted a position at Purdue University in the Fall of 1929 as Associate Professor of Geology. He was promoted to

Professor in 1935 and in 1947 he was also made Chairman of the Division of Geology in the School of Chemical and Metallurgical Engineering. In addition to his teaching and administrative work he continued his consulting work. He became a consultant to the Indiana Limestone Company of Bedford in 1931 and this led to his outstanding success in finding a non-staining cement for limestone building construction. He also became a consultant on coal to the Western Division of the Pennsylvania Railroad Company in 1944.

Professor Serviss was an outstanding teacher. He kept his courses up to date by constant revision through his intensive and extensive reading of the pertinent current scientific literature. Also he strove to give his students a comprehensive knowledge of mineralogy and geology from both a technical and an economic point of view. He insisted on orderly work as well as orderly thinking and his laboratories were maintained with efficiency and order. He had the ability and the professional background to do productive research. However, owing to the death of his wife in 1941, leaving him with nine children to take care of, he devoted much of his time, not necessary to his teaching, administrative, committee, and consulting, to his family and he succeeded well in bringing them all safely to maturity before he passed away quietly in his sleep on July 22, 1954. However, he had published articles on metallic minerals; crystal growth; economic geology; and the political effect of mineral deposits of economic importance and their national significance.

He maintained membership in numerous scientific societies. He had been a member and Fellow of the American Association for the Advancement of Science since 1933, a Fellow of the American Geological Society, and a member of the American Institute of Mining and Metallurgical Engineers, the American Society of Civil Engineers, the Association of Petrological Geologists, the American Academy of Political and Social Science, the Academy of Political Science, the American Geophysical Union, and the New York Academy of Science. He was also affiliated with Sigma Xi, Tau Beta Pi, Pi Tau Sigma, Phi Lambda Upsilon, Sigma Gamma Epsilon, and Chi Epsilon, all honorary societies. He served as adviser to the Purdue Catalyst Club and the Purdue chapter of Sigma Gamma Epsilon. He was a registered engineer in the States of Indiana, Illinois and Colorado. As a citizen he was a member of the Board of Advisers of St. Francis Catholic High School in Lafayette. Professor Serviss was listed in Who's Who in America and in American Men of Science.

He joined the Indiana Academy of Science in 1938 and presented and published one paper on "Geophysics in Training a Geologist" in the Proceedings for 1938.

Professor Serviss was at heart a scholar. A devoted father and fine counselor of youth, a fine teacher and efficient administrator, his loss to Purdue and his community is great. Likewise, Industry has lost an excellent counselor and the State a good scientist and citizen.

THE FUNCTION OF OUR SCHOOLS IN PRODUCING SCIENTISTS

Otto B. Christy, Muncie, Indiana

It has been my privilege and opportunity to observe and to participate for many years in the teaching of science on the elementary, secondary, and college levels. I have witnessed science and its application through a period in which it has given us marvelous drugs and many ways of diagnosing our ills and many ways of improving our health. It has brought about wonderful improvements in transportation, communication, and has given us luxuries of every sort. Recently it has given us a most powerful tool—the atomic energy with all its potentials.

Now, if I have any contribution to make in the field of science I choose to make it in the field of science education and particularly in the field of teaching, for in this field lies a lifetime of interest and experience.

In this new age of progress in which science is playing such an important part in our lives, we need a better understanding of science in all its aspects. It is only through the general understanding of its principles and applications that we can expect to continue advancement and leadership of our American Democracy. More and more we are going to need a general understanding of science for ourselves in our daily living and for those in positions of authority who understand and direct the forces which develop a constant and growing need for a supply of trained science personnel—personnel to make new discoveries in drugs and techniques, new machines, and new ideas for better conditions of mankind.

This places our educational system, and particularly the teacher, in a strategic place. How can we expect to obtain the desired growth in the various fields of scientific development without a carefully planned emphasis upon the basic educational principles underlying the development of scientists?

The disturbance caused by two world wars within one generation followed by a period of rapid development in many fields of human progress has stimulated a general interest in science. Industry has been adding millions to her annual expenditures for research and new scientific developments. The federal government has increased her budget from year to year in order to improve our plants and animals and to control their enemies. Congress has been willing to appropriate almost unlimited amounts for research and for development of new machines and new weapons. The demand for engineers, technicians, and research workers in the many fields of endeavor, as well as a need for an enlightened public concerning science and its practical application in this new age, has placed a tremendous responsibility upon our entire school system. Educators and scientists alike have pointed out the maladjustment which exists between needs for scientific knowledge in our human population and the production of the end product through our school system.

After watching the growth of science in our elementary and secondary schools, and institutions of higher learning for many years, I can recognize that much progress has been made through the efforts of curriculum builders, conscientious teachers, and school officials. The help of outside agencies in promoting scholarships and other types of encouragement to youngsters and students who possess an interest and ability in science has been encouraging. However, I am convinced there remains a great opportunity to improve the achievements of our entire educational system in the field of science. We need to organize the sciences into a more effective and coordinated program as an instrument of education if we are to lead the forces of social advancement in this new age.

In my opinion the greatest improvement in science education during the last decade has come in our elementary schools. It is true also that in this area the greatest opportunity for effective remedy lies. It is in this formative period in the life of an individual that science instruction will stimulate interest and arouse curiosity which often proves to be the starting point in a successful career. It is during the period from the ages of six to twelve that the child learns to read and the desire to learn is stimulated. A vast amount of information opens up to him and he begins to manifest a keen interest in his environment. He becomes intrigued by everything that is alive. He is fascinated by the toys and machines that move as well as the sky above and the rocks and streams below.

The good teacher understands that the use of science in her daily work is fundamental in the child's educational development. She will make constant use of the vast storehouse of subject matter material which is always present in the child's environment. The interest in science at this early age is, as many scientists will testify, the beginning of a scientific career. The teacher who fosters this interest and helps to solve the child's problems in science multiplies his chances of continuing the interest into the secondary schools and into the higher fields of education.

It has been reported that potential scientific careers can be discovered in these early years. Some of the signs which indicate scientific potentialities in the boy or girl are his curiosity in what makes things work and how he can improve them; his ability to observe carefully; his ability to concentrate and work untiringly to solve a problem; his interest and capacity to do mathematics and his willingness to work independently. If a child manifests these characteristics they are worth more for guidance than any tests now devised. Yet, a teacher must remember that in this early period a child's curiosity can be easily encouraged or it may be frustrated beyond recovery.

Granting that much progress has been made in promoting science in the elementary school system, I would like at this point to indicate some of the weaknesses which exist and suggest some possible solutions for consideration. First, may I point out that many elementary teachers do not feel adequately prepared to teach science. Even when the curriculum has a definite place for science, teachers too often ignore the subject and say that children know more in this field than they themselves. Other excuses sometimes given include not enough time for the subject; no place for materials; or it takes too much time for preparation—none of which are really valid reasons. The one excuse which is seldom heard is that the child is not interested in science.

The result of this neglect on the part of many elementary teachers is that many youngsters who have potential possibilities are sadly neglected and lost to the field of science.

Second, an analysis of the background of many elementary teachers shows that they are poorly prepared in the field of science. This may not be the fault of the teacher but a weakness in the institution in which the teacher was trained. Professors of science are usually specialists in some particular field and regardless of how efficient they are in presenting their subject to science students they may be utterly inefficient in presenting the needed material to the prospective elementary teacher. These instructors usually make their courses too difficult and too technical to meet the needs of the non-specialist. To be a good instructor of science on the elementary curriculum the instructor needs a broad background and should have enough basic understanding of children and the educational principles involved to choose wisely and present effectively science material to meet the needs of prospective teachers.

In some colleges and universities the science staff is not particularly interested in the elementary field of teacher-training and therefore this job is left largely to the Department of Education. Here we may have an array of Ph.D.'s, Ed.D.'s, Ed.M.'s, Ll.D.'s, etc., but too often these staff members have had courses concerning all the fields of how to teach, but little knowledge of the subject matter they are to teach. Naturally in this case the department will be loaded with required and elective courses in education. The prospective teacher under such guidance may therefore have little interest in science as a basic subject for meeting the educational needs of children. Or she may make much use of the many interesting and valuable elementary science books now coming from the press, but she will use them to stimulate reading and not to teach science. In my opinion there is a wide difference. These science books with their excellent choice of material, beautiful illustrations, and appropriate vocabulary are superb for motivating reading, but they should also be used for creating a scientific attitude in the minds of children.

Many elementary teachers need encouragement and stimulation to undertake the problem of teaching science. Superintendents, principals, and supervisors have an opportunity to be of great service and in turn to make a big improvement in the school program and its function in developing the educational growth of the child.

School officials have this opportunity but too many make little use of it. Perhaps this can be explained in many cases by the lack of science training which the officials themselves have had. Again the requirements for administrators on their college curricula have placed emphasis on how to teach the various subjects and how to handle the various school and community problems, with too little opportunity left for acquiring a knowledge of the basic courses of education. The result of such a background is too often lack of interest and too little knowledge of science to appreciate its value in the welfare of the child.

Another weakness in our elementary program appears when dealing with children who manifest an interest in science and mathematics. These youngsters are often in the upper percentile and should be able to progress more rapidly through the more difficult subjects. They should have some special attention and encouragement. They should be kept busy lest they lose interest and consequently become habitual loafers. This situation may mean the loss of promising young scientists to society.

In our present educational system of training teachers the colleges are providing many courses with the idea of giving teachers and school administrators a background for dealing with the handicapped child. Such courses include: Problems of the slow learner; problems of the non-reader; treatment of special disabilities in reading; personal adjustment of the child; handicapped school children; education of the slow learner; etc., but, little attention has been given to the problems of educating the exceptional child. Therefore, many teachers and administrators find themselves at a loss to direct the above-average or brilliant student and he too often becomes the neglected child.

If the public schools are dedicated to the task of providing equal and maximum opportunities for each child, then there should be no discrimination. Each child from the slowest learner to the most gifted should have those educational experiences which will give him the maximum growth which the schools can offer to him. With this objective, the subjects of science and mathematics will become key subjects in guiding capable youngsters into the various fields of scientific leadership.

Now if we focus our attention upon our secondary school system, we will find much to commend in the progress it has made. New buildings, new equipment, new modes of transportation, new courses have been added and the growth in the number and convenience of the high schools has been phenomenal. May I cite one example to show this progress? When I was a youngster, there was only one high school in my county, Vigo, and it was located in the county seat of Terre Haute. Now there are twenty-three and every township except one has at least one junior or senior high school and the city of Terre Haute has eight. My first experience in high school was in one room with one teacher who taught Latin, Algebra, Ancient History, English, and no more. Music, gym, science, home economics, agriculture and industrial arts were unheard of. How times have changed. Now, after a half-century of progress we find ourselves in a new situation—a situation in which science is playing a most significant part in our daily lives and our future thinking with every indication that a greater development is rapidly on the way.

Our high schools have done much to keep pace with this rapid growth, but there are some definite needs for changes if these schools are to do their share to produce the needed scientists for this modern age.

It was upon this occasion 27 years ago that the late Frank B. Wade, then president of the Academy, criticized our high school system for doing too much testing and not enough teaching of basic subject matter material. Said Mr. Wade, "*More Scientific Education; Less Educational Measurements.*"

Since then we seem to have passed the testing fad until now it has assumed its proper place in the educational program, but the need for more emphasis on science is even greater today than it was in Wade's day. Of course, since his day the population of our high schools has increased many hundred per cent until now nearly everyone of eligible age may be admitted, and our high schools have been reorganized until they attempt to accommodate all regardless of their ability or interests. Some of these students are barely able to read and probably never will do much better, but they are provided with the opportunity to learn many skills which will enable them to become useful citizens. This is a great change in public attitude toward its responsibility in education. It is a good example of democracy in action.

To make the necessary change to fit this philosophy of education the curriculum has had to be revised and many new types of experiences have been added. Many high schools are now offering courses giving credit in carpentry, brick laying, auto mechanics, printing, practical arithmetic, and English, athletics, and music of all sorts, as well as many other satisfying and useful courses. Any of these courses may be challenging and necessary to the career of the student, but many are organized and taught in such a manner as not to be most challenging to the serious minded student who is looking toward a professional career. These courses offer temptations to the science-minded individual. Taking them limits the amount of time to be spent in the basic subject matter courses. They are frequently an enticement to bad habits of study. Even under our best guidance programs the counselors find it difficult to persuade the scientific and mathematical-minded students to follow the less spectacular courses.

The effect of this temptation may be a factor in the reduced enrollment in our high school science classes. According to Professors Heiss, Obourn, and Hoffman—"In 1900 twenty per cent of the high school student population studied physics. Today less than six per cent of the high school students are enrolled. Only about half of the nation's high schools now offer the subject."

Again, as in the elementary schools, we find too little effort to provide the rapid learner with enough difficult and useful problems necessary to direct him into the career most useful to his welfare and to society. The gifted youngster seems to be the forgotten man of our educational system. High school teachers as well as all others should be aware of the opportunities and the responsibilities for developing in youth those qualities of mind which will be of greatest worth in meeting the social and economic problems of which they are capable.

The fact that there is such a shortage of well-trained scientists for teaching and for research in industry and government indicates that students are being lost somewhere along the line. Much of this loss through the junior and senior high schools may be attributed to an inadequate curricula and the poorly-trained teachers too often found in the smaller high schools. Here we find the bare minimum of courses in science scheduled with poor facilities for doing good work.

I have known several teachers of science in Indiana who were struggling along with classes in biology, general science and even in chemistry and physics with little or no equipment and no allowance by the school officials for the purchase of supplies. It seems to be a common practice for teachers to spend the entire semester in the classroom without making a single excursion into the field or to an industry, or even worse, without applying the scientific principles of science to life situations. This state of affairs leads to a textbook course in which the student receives little encouragement to challenge his scientific ability.

This lack of interest and support of science is further shown by the type of teacher employed. Granting the fact that there are an insufficient number of science teachers, too often it is the home economics teacher who is in charge of the biology classes. She may be an excellent teacher in her field but she may also be teaching biology on a permit and manifesting little interest in the subject. The teachers of physical sciences as well as mathematics, too, are often teaching on permits with their major interest in social science, athletics, or other subjects.

These are unhealthy situations which will require many years to adjust. In the meantime it will be necessary for more students to become aware of the opportunities in the various fields of science. It will be the responsibility of teachers and school officials to provide better conditions for learning science and to place greater emphasis upon guidance toward scientific careers.

The present dire need for many more capable science students in our high school classes has been recognized by industries for some time. They are aware of the fact that unless an adequate number of strong high school students is maintained our colleges and universities cannot meet the growing demand for engineers and technicians so badly needed. Industry has for a number of years suffered from a shortage of well educated and skilled personnel and is now offering scholarships and other inducements to the more promising high school graduates who will pursue their science studies into our colleges and universities.

According to Time Magazine—"Few people know how much industry already contributes. In 1954 business will donate well over $60 million to private U. S. colleges, plus additional funds for research and equipment. Du Pont will parcel out more than $700,000, most of it for chemistry students' research. Union Carbide has gone even further. It is planning a $500,000 program which will eventually provide 400 scholarships a year for more than 30 colleges to administer without strings of any kind."

Another good example of how industry recognized the importance of this problem is the work done by the Bausch and Lomb Optical Company. In 1932 this company became aware of the growing shortage of scientists and decided to establish a Science Award Program. This program was designed to give recognition to outstanding science students in our secondary schools and to encourage these students to seek careers in science. Since the establishment of this program, 22 years ago, over 22,000 students have been given Bausch and Lamb Honor Awards. The company reports the following—"There is a wealth of evidence pointing to the fact that awards have had a tremendous impact on the careers of thousands of the winners. . . . In 1951, for example, a study of *American Men of Science* revealed that 148 winners of the Science Award Medal had already achieved scientific status. . . . In the period between 1933 and 1940 a tabulation showed that 94 per cent of those receiving awards attended college, 44 per cent received two or more degrees, 54 per cent were elected to honor societies, 85 per cent were actively engaged in scientific or educational careers."

One of the most attractive of these inducements comes from the Talent Science Search made by the Westinghouse Educational Foundation and is being promoted in Indiana by this Academy through the leadership of R. F. Lefter and his committee. In this plan Westinghouse offers to the seniors of 27,000 public, private and parochial high schools of the United States an opportunity to compete for the $11,000 in scholarships to continue their education in science. From the fourteen thousand or more entries in this annual contest forty will be selected as national winners and receive a five-day all expenses paid trip to Washington, D. C., to attend an Annual Science Talent Institute. Another 260 of this group will be recommended to colleges and universities of their choice. Many of these will receive offers of financial assistance toward a college education from other sources on the basis of this honor.

During the past year, in cooperation with the Westinghouse Educational Foundation, the Indiana Science Talent Search Committee selected 30 of Indiana's contestants as state winners from the 98 who completed entry requirements for the Search. These state winners and their teachers are invited each year to Indianapolis for a luncheon as guests of The Indianapolis Times. To see and hear these junior scientists demonstrate their projects leaves one absolutely amazed to find such talent among our high school boys and girls.

As you well know, the State Academies of Science are promoting Junior Academies of Science. In Indiana this is being done through H. H. Michaud and his committee. We of the Senior Academy can feel a sense of pride in the results of this project and should continue to cooperate with it. These young scientists will hold their annual meeting in this building tomorrow, with over 200 boys and girls representing 35 or 40 science clubs from the high schools of Indiana in attendance. The encouragement given to these clubs will no doubt do much toward stimulating their members to continue their science interests.

It may be noted that a high percentage of the Science Talent Search contestants, as well as the Junior Academy of Science Club members, come from the larger high schools. Few entries and practically no winners of the Westinghouse contest come from small high schools. Likewise the science clubs of Indiana are in our larger schools. Perhaps this can be expected but certainly it does not indicate there are no boys and girls in the smaller communities interested in science or capable of pursuing scientific careers.

Since our institutions of higher learning must depend upon the secondary schools for their recruits in engineers and technicians, and since there is such a shortage in trained personnel in all fields of scientific endeavor it behooves these institutions to use every legitimate means available to meet this demand.

The large sums which have been given or appropriated for buildings and laboratories are important for good work, but the greatest factor for attracting and developing good scientists lies in the teaching personnel. The teacher problem in one form or another is always with us and always will be, but it is doubtful if any phase of our educational program needs more immediate attention than the supply of skilled science teachers on all levels.

A lifetime of teaching does not necessarily qualify one to dictate how a science teacher should be educated or how he should conduct his classes. The field is too broad and too varied for that, but such a background of experience enables one to draw certain provisional conclusions. Among these which apply to teaching on the college level are:

A more comparable salary scale for the college instructor with that of industry. Too often the prospective teacher is lured into business and industry by the higher salaries. If the colleges are to maintain a high standard of professional personnel they will need to employ some of their best product for their staff.

College officials when employing staff need to recognize that good research men, good mathematicians, or good engineers are not always good teachers any more than good teachers are always good in the practical field of science. Therefore, due consideration for the ability to teach effectively should be fundamental and of primary importance.

College classes in science and mathematics are frequently too large to give the student the proper guidance. Too little attention is often given to the inexperienced graduate assistant who has much of the responsibility in helping the perplexed freshman with his problems. A freshman thrust into the strange life of a college very definitely needs the personal help of the best teachers.

While I do not feel competent to judge the merits of the teacher-training program in our colleges, I have a strong feeling that some science departments are neglecting this important responsibility. We need good instructors of science and mathematics in our colleges as badly as we need good engineers or good researchers in industry, and some institutions would do well to make a re-evaluation of their teacher-training program in the light of this need. In the employment of instructors, institutions should remember that just because a person is an expert in a particular field does not necessarily mean that he can be a successful teacher in this field. To expect the highly-trained chemists, or physicists, or mathematicians to instruct without some knowledge of the learning processes or the techniques of teaching is expecting too much. All teachers in our public schools are required to take many so-called professional courses before they are allowed to teach. No doubt this phase of their education is overemphasized, but since there are no such requirements for teaching on the college level, it would seem advisable that some professional preparation would be quite useful. The instructor with no professional training may be a good teacher, as is often the case, but he has learned to be one the hard way and no doubt would be a more skillful teacher had he received some specific training for the job.

Lest I be misunderstood by the emphasis herein made on the importance of the teacher and the schools in the production of scientists I wish to make clear that I am fully aware of the many other factors which must enter into the making of a scientist. First of all he must be born with a good mind and with many of the attributes necessary for scientific development. Scientists, like other great men, must come from ancestry capable of producing great men.

Then to achieve distinction one needs to come under the influence of one or more persons who can inspire him and arouse his ambition to succeed; and here is where the teacher has a golden opportunity. We are familiar with the effect which Professor Winslow had upon the life of Charles Darwin or the scores of scientists who sat at the feet of Louis Agassiz, or the many good scientists who were inspired to distinction through tramping over the hills of southern Indiana with David Starr Jordan, or sitting in the classes of Roscoe Hyde at Terre Haute and Johns Hopkins University.

To be sure science in education has developed slowly but substantial progress has been made. Nevertheless the present status of our educational program in science is somewhat disturbing. In the light of the tremendous scientific advancements made during the last two decades I feel very definitely that our educational program has not kept pace. It is true that our citizens have become much more aware of the scientific progress being made, but much of this information has come from other sources rather than through the schools. The press, radio, and TV sets are powerful forces in informing the public of scientific progress. These are all stimulating forces and when added to other forces such as the science fairs, the science talent search program, and the many science clubs, they should form powerful factors in aiding the elementary and secondary science programs. The college students also have much to encourage them toward science careers through scholarships and other economic inducements. The demand for more and better prepared graduates for science teaching and for research in industry will assure an increased interest in the various fields of science and mathematics.

Now, as we pass the mid-century mark, I beg to conclude with the happy thought that we are evidently passing the most critical stage of our science educational problems and the outlook is full of promise. We can expect a richer science program in our elementary schools. Our high schools and colleges will have larger enrollments with better-prepared teachers. We can look forward with unshaken confidence that our educational system will not fail us in this hour of need. Our progress has become too dependent upon the good teacher, the scientist and his laboratory for a long continued delay.

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ANTHROPOLOGY

Chairman: THOMAS B. NOBLE, Indianapolis
JOHN JONES, Indiana University, was elected chairman for 1955

ABSTRACTS

Rain Ceremonies of Central Mexico. THOMAS J. MAXWELL, JR., Indiana University.—Ceremonies having to do with weather control have survived in present-day Mexican ritual. Similarities between the present rites and those of the sixteenth century Indians of the same area are evidence in the dances, the all-night vigils, processions carrying various images to certain places of worship, pilgrimages to sacred streams and pools, offerings to the images and to the deities at the water pools. Other similarities are suspected but the evidence for them is not yet at hand.

These survivals have also been found present in the Central Andes. In addition, there are present there yet beliefs in the effect of smoke on weather, the irritation of unsatisfied mountain spirits, the appeasement value of blood from between the eyes, the value of captured frogs in directing the attention of rain deities, and the interference of ancestral spirits when their bones are neglected.

Of these, smoke, frogs, bones of the dead, and irritated mountain spirits are known to play a part in Mexican ritual but to a lesser extent. Further study, it is believed, will tend to demonstrate the reasons for similarities between these two areas in all time periods historically described.

The "Yahooskin Snakes" of South Central Oregon. ERMINIE W. VOEGELIN, Indiana University.—For several decades the Yahuskin Snakes have been accepted as a Northern Paiute-speaking band which, in aboriginal times, was located in what is now south central Oregon. Such acceptance was based on the fact that 1) a treaty was made in 1864 with "Snakes" designated as "Yahooskins," and 2) that the Yahuskins are mentioned frequently after the treaty was made, by Oregon Indian Office officials in their reports to the Commissioner of Indian Affairs. From close analysis of heretofore unused documentary material, undertaken in an effort to identify and localize the Lahuskin with exactitude, it is now evident that this group had no aboriginal validity. The treaty-signing Yahuskin of 1864 were in reality a score of Northern Paiute, deriving from the Surprise Valley region in northeastern California and south-central Oregon; the post-treaty, Klamath Reservation Yahuskin of Klamath Agency records were actually a small Klamath-speaking group, which up to now has been virtually unnoticed in the literature. This small Klamath group occupied a strategic position between the Klamath Marsh-Upper Klamath Lake Klamath groups to the west, and the Northern Paiute-speaking people ("Snakes") to the east.

The confusion that has existed regarding the identity and provenience of the treaty and post-treaty Yahuskin arose from four main causes:

abysmal ignorance concerning the Northern Paiute-speaking people of central and eastern Oregon on the part of Indian Bureau officials in the latter half of the 19th century when treaties were being attempted with them; manipulation of Klamath Agency funds and groups to meet very real exigencies in the troubled 1860's and '70's; misinterpretation or neglect of relevant documentary material relating to the Klamath and the westernmost Northern Paiute by ethnographers, as well as a general uncritical acceptance by ethnographers of treaty-designated groups as valid aboriginal groups. These four main causes become obvious as we examine in detail the history of the so-called Yahuskin Snakes.

Preliminary Sketch of a Contemporary Arawak Community. NANCY P. HICKERSON, Indiana University.—The Arawak are a Tropical Forest people native in littoral British Guiana. Their current habitat, however, is restricted to inland waterways by the coastal settlement of non-aboriginal peoples (European, African, and Asiatic).

A modern Arawak community at Tapakuma Lake, Essequibo, has a two-fold economy: the subsistence pursuit is agriculture, based on the aboriginal crop, manioc. In addition, timber-cutting and absentee work provide cash income; cash is circulated within the community as payment to hunters, fishers, and craftsmen.

The social and household unit is the nuclear family; tendencies are to community endogamy and matrilocality. Both patrilineal European surnames and matrilineal sib-names are held.

Some obtrusive aspects of custom are cooperative work parties climaxed by drinking sprees, girls' puberty ceremonial, a shamanistic divination pattern, and the well-known Guianese *kanaima* complex. Old and New World features blend in many parts of the culture—language, kinship, and folklore, for example; all three are basically Arawak with incorporation of European elements.

Religious and economic ties with the greater Guianese body politic are crucial in maintaining the Tapakuma settlement: These Arawaks are "mission Indians" in that the missionary in bestowing patronage attracts adherents, and "trading post Indians," in that the timber-trade provides an economic basis for maintaining a stable local group of considerable size (18 households containing over 60 individuals).

Alcoholic Beverages in Native North America. HAROLD E. DRIVER, Indiana University.—For the world as a whole, there was a high positive correlation between the geographical distribution of farming and that of alcoholic beverages as of A. D. 1492. South America conformed to the general picture, with the majority of tribes engaging in farming and also in the making of beers and wines, almost always from the plants which they cultivated.

North America was more deviant. Only about half the tribes farmed and only about half of the farmers (one-fourth of the total) manufactured and drank alcoholic beverages. The alcoholic consumers were almost exclusively confined to the Southwest, Mexico, and Central America. Furthermore, only about half of the total quantity of wines or beers produced was made from cultivated plants such as maize and tapioca. The other half was manufactured from wild plants such as mesquite and cacti.

There was a sizable area in northeast Mexico where farming was unknown but where fermented drinks were made exclusively from wild plants. The process all over the Americas was limited to natural fermentation which produced drinks of only four or five per cent alcohol. Distillation was unknown before European contact but spread rapidly after its introduction. Although some drunkenness prevailed in aboriginal times, the vitamins, calories, and other nutritious elements of alcoholic drinks, not to mention the water content in desert areas, outweighed the evil effects.

A Preliminary Report on the McKinley Site. J. C. HOUSEHOLDER, Indianapolis.—The McKinley Site is located in Hamilton County, Noblesville Township, Indiana, about one mile south of Noblesville.

The Village has been reduced from 2/3 to ½ of its original size. At the present time it is about 600 feet long and 200 feet wide. It is located on the second terrace overlooking White River.

Over a period of years, surface collections have been made. We have been excavating this Village for the past two seasons (1953-1954). The entire picture of the pre-pottery culture is quite different from the historic peoples we are familiar with (at present in this area, we have removed twelve burials, antler points, worked bone, worked bone awls, antler tubes, a few very small shell discs, a cash with pestel, hammer stone, rubbing stone and a very little worked flint). This picture may change after it has been analyzed and a carbon dating made. We can safely say the McKinley Site is of great antiquity.

A Statistical Justification for 15 Years Excavation of One Archaeological Site. GLENN A. BLACK, Indiana Historical Society.—To many it would seem incredible that 15 years could, or should, be devoted to the exploration of one archaeological site. The cultural complex involved (the Middle Mississippi) has a richness and existence pattern which is conducive of a multitude of material traits and cultural elements. The potential of no Middle Mississippi site has ever been plumbed and since Angel Site has every attribute typical of this complex the opportunity for exhausting the statistical potential justifies the time required to do so. The data derived will be usable for generations as the pattern of life of these folk.

BACTERIOLOGY

Chairman: DOROTHY POWELSON, Purdue University
H. A. DETTWILER, Eli Lilly and Company, was elected chairman for 1955

ABSTRACTS

Antigen-Antibody Reactions in Agar. ROBERT K. JENNINGS, Northwestern University, Chicago.—Antigen molecules diffuse from a mixed source into gel with remarkable independence. The distribution of each component resembles that which would be obtained if other components were absent, and may be made apparent by the precipitin reaction. Within the past six years, half a dozen methods of applying this principle to the analysis of complex biological materials have been reported.

"Simple diffusion" methods, such as Oudin's, use antibody in agar as indicator for antigen diffusing from a superimposed solution. The apparent migration of the precipitate as equivalence is established at points increasingly remote from the interface occurs at rates which are diagnostic of the concentration and diffusion coefficient of the antigen. "Double diffusion" methods use an arena of clear gel, between antigen and antibody, within which overlapping gradients establish equivalence. Applied in plate methods such as Ouchterlony's, the resulting precipitate patterns demonstrate identity or non-identity of unknown and reference reagents.

Applications reported include studies of chemical purity, of the antigen spectra of tissues from animals or insects and of bacterial culture fluids, as well as methods of screening animals for antibody production, bacteria for antigen production and many others. Even greater versatility may be anticipated as the methods are further developed and refined.

Techniques for Studying Bacterial Population Changes and Some Recent Applications. WERNER BRAUN, Camp Detrick, Frederick, Maryland.—A number of useful techniques for analyzing the occurrence of bacterial population changes and factors controlling such changes will be reviewed. The application of such techniques will be illustrated by reference to recent studies on the effects of DNA upon population changes in *Brucella.* These studies revealed two entirely different effects of DNA: (1) transformation-like phenomena which occur when competent strains are exposed to highly polymerized heterologous DNA, and (2) a nonspecific selective effect, which involves an inhibition of growth of the parent type cells while favoring continued growth and the rapid establishment of mutant type cells. The latter effect can be observed with certain strains following addition of any bacterial DNA so far tested after it has been briefly exposed to DNase (Braun and Whallon, Proc. Nat'l Acad. Sci., March, 1954). The intensity of the selective effect depends greatly upon the production of a compound produced by mutant cells in the presence of enzyme-treated DNA. Some information on the general nature of this compound, indicating that it is a nucleotide, has been obtained in studies on the selective effects of variously treated filtrates obtained from mutant cultures containing DNA + DNase. In certain media similar selective effects also occur when cultures are supplemented with *only* DNA or *only* DNase. This was found to be associated with the natural accumulation of DNA and DNase in most media; the differences in effectiveness of various media in producing the selective effects are due to medium-dependent differences in the ability of DNase to act upon DNA.

An acetyl-coenzyme A and succinate requiring enzyme from Azotobacter. R. REPASKE, Indiana University.—When studying the characteristics of a partially purified succinic dehydrogenase from *Azotobacter vinelandii (o)*, it was found that acetyl-coenzyme A had a stimulatory effect on the reaction. The stimulatory reaction was the result of a second enzyme(s) which was separated from succinic dehydrogenase and required succinate and acetyl-coenzyme A as substrates. The reaction as measured by 2,6-dichlorophenol indophenol reduction appears to occur in at least two steps. The first reaction occurs in the absence of dye and involves the acyl bond of acetyl-CoA. The second step is associated with dye reduction; when the reactants are preincubated without dye, the subsequent rate of dye reduction is directly proportional to the preincubation time. The overall reaction has a pH optimum of 6.6, and the enzyme(s) is equally stable at pH 6.5 and 8.5.

The enzyme has been purified 9 fold from the spinco supernatant fluid from alumina ground cells. Purification and properties of this enzyme(s) will be discussed.

The Mutual Effects of Ca^{++} and Antimicrobial Drugs on Coagulation of Plasma. E. D. WEINBERG and M. B. TOLZMANN, Indiana University.—Ca^{++} combines chemically with oxytetracycline, reverses bacterial toxicity of streptomycin, and is more readily assimilated by chicks on a diet containing penicillin. Each of these antibiotics, in high concentration *in vitro*, inhibits the coagulation of blood. The present study was performed to determine if the anti-coagulant activity of oxytetracycline, streptomycin, and penicillin is reversed by the addition of Ca^{++}. Also included in the study were chlortetracycline, chloramphenicol, and sulfanilamide; and the sodium salts of citrate, oxalate, and ethylene diamine tetraacetate.

The 9 test substances were added individually to various samples of citrated rabbit plasma (Bacto-coagulase) in the presence of varying amounts of Ca^{++}. Addition of chloramphenicol or sulfanilamide had no effect on the amount of Ca^{++} required for optimum clotting; addition of each of the other test substances increased the amount of Ca^{++} needed. With the 7 active test substances, two general effects were obtained: inhibition of coagulation in the presence of "normal" concentrations of Ca^{++}, and stimulation of coagulation in the presence of excess concentrations of Ca^{++}. In addition, the anticoagulant activity of *high* concentrations of 3 of the 7 substances (oxytetracycline, chlortetracycline, and penicillin) was not reversed by Ca^{++}. Apparently these 3 drugs inhibit coagulation by an additional mechanism as well as by combining with Ca^{++}.

A Study of Antibiotic Producing Bacteria From the Soil. C. L. BALDWIN, BETTY PETERS, CATHERINE NORTH, HAROLD A. NASH, Pitman-Moore Co.—The approximate numbers and inhibition spectra of antibiotic producing organisms among the gram-positive aerobic spore-forming and gram-negative bacteria occurring in soil were studied.

A total of 284 soil samples from nation-wide sources yielded a total of 1,147 antagonists when screened on agar dilution plates. Gram-positive antagonists were detected by spraying or over-laying with *Brucella bronchiseptica*, *Mycobacterium* sp. #607, and *Trichophyton mentagrophytes*. Gram-negative antagonists were also detected with indicator organisms after the soil bacteria had developed on crystal violet agar or at 5 C. on trypticase soy-agar.

The soil samples which yielded antibiotic producing gram-positive organisms contained on the order of 150,000 antagonists per gram. The samples exhibiting gram-negative antagonists yielded about 25,000 per gram by the crystal violet agar method and 5,000 per gram by the cold incubation method.

Routine determination of antibacterial spectra against ten test organisms revealed the gram-positive isolates to have slightly broader antibacterial spectra than did the gram-negative isolates. Almost half of the former inhibited five or more of the test organisms whereas of the latter group less than one-third did as well. Three per cent of the total isolates were effective against all ten of the test organisms. Antagonists isolated for activity against *Brucella bronchiseptica* and *Mycobacterium* sp. #607 were superior in breadth of antibacterial spectrum to those isolated against *Trichophyton mentagrophytes*. Comparison of the spectrum patterns allowed the most active cultures to be classified into 65 groups, each containing from one to 80 replicates.

The Effects of Fixatives on the Internal Structure of Bacteria. DONALD J. MASON and DOROTHY M. POWELSON, Purdue University.—Changes in the internal structure of cells of *Escherichia coli*, strain 61, and *Bacillus cereus*, strain CR, produced by the action of fixing agents were studied by phase contrast microscopy. The fixatives used were Bouin's solution, a mixture of methyl alcohol, picric acid and formalin, osmium tetroxide and formalin. Special slide preparations permitted the same cell to be photographed before and after fixation. Fixation increased the differences in contrast between the cytoplasm and the "nuclear" areas of the unstained cells. The original appearance of the cells seemed to be disturbed by fixation less with formalin or osmium tetroxide than with Bouin's or fixatives of the methyl alcohol type which caused distortion within the cells. Cells fixed in Bouin's solution contained large granular-like clumps which were probably precipitated proteins.

Fixing in 2% osmium tetroxide solution for longer than two hours produced a latent effect. After the fixed cells were hydrolyzed in N HCl at 60 C, the hydrolysis commonly employed in the Feulgen reaction, the cytoplasm had a retracted appearance.

The Role of Nutrition in the Host-Paraside Relationship. E. D. GARBER, The University of Chicago.—The role of nutrition in the host-parasite relationship has been explored by means of biochemical mutants of an animal and of a plant pathogen. The data indicate that the avirulence of certain biochemical mutants is related to the unavailability of the required nutrilites in the host either at the site of entry or localization. In the case of the plant pathogen, unavailability of required nutrilites was related to the inability of certain biochemical mutants to produce a proliferating or metabolizing population because of the relatively low concentration of the required nutrilites at the site of inoculation. The probable significance of this interpretation for the virulence of obligate parasites or pathogens with exacting nutritional requirements will be discussed.

Some Applications of Isotopes to the Study of Microbial Physiology. E. C. HEATH, Purdue University.—It has become increasingly evident, with the availability of labeled intermediates from commercial sources, that the purity of these compounds must be critically established before their use experimentally, since a small trace of radioactive impurity can cause error in interpreting results. Experiments with radioactive compounds frequently are performed to follow the incorporation of label into metabolic intermediates. Specific activities of intermediate compounds often offer clues to the sequence of biochemical reactions taking place. Care must be exercised in these determinations to take into account pool amounts of the individual intermediates being studied. Instances arise in which it is desirable to add unlabeled carrier in order to isolate minute amounts of suspected intermediates. The failure of label to appear in the reisolated carrier compound does not necessarily indicate that the compound is not an intermediate, since the added carrier may not equilibrate with the pool of the same compound in the cell due to the latter's presence in a bound state. Respiratory CO_2 yields valuable evidence for metabolic mechanisms but it is necessary to correct specific activities of CO_2 for endogenous CO_2 production. These problems will be discussed and experimental examples of them which have been encountered will be considered.

BOTANY

Chairman: Richard Starr, Indiana University

A. L. Delisle, University of Notre Dame, was elected chairman for 1955

ABSTRACTS

Some Aspects of Sexuality and Genetics of *Cosmarium botrytis* Meneghini. Richard C. Starr, Indiana University.—The use of desmids in various lines of experimental research has been limited by their failure to reproduce sexually when grown in culture. Successful cultivation of desmids has been reported by a number of investigators during the past fifty years but it was not until recently that the writer isolated strains of *Cosmarium botrytis* in which sexual reproduction can be effected at will. Genetic studies show that mating type is inherited as a single gene.

A lethal factor has been shown to be present in one of the parental strains. This factor is undetectable in the haploid vegetative cell and in the heterozygous condition in the zygote. It is only when both gametes carry the lethal factor that the resulting zygote lyses shortly after formation. The lethal factor appears to be inherited as a single gene unlinked with that of mating type.

Further studies are in progress involving the inheritance of cell size and shape.

A Preliminary Report on a Study of Variation in *Spirogyra*. M. Ann Allen, Indiana University.—Investigations are being made on life histories of certain strains of *Spirogyra* in culture in an effort to better understand variations which have appeared. Studies are being directed to see if the variations might be correlated with nuclear behavior, chromosome number, and environmental conditions.

Filaments of at least three different widths have arisen in an original clonal culture in soil water medium. Three width types: Type 1 (15.3μ), Type 2 (23.3μ), and Type 3 (30.5μ) have been designated. Reisolated single filaments of Type 1 give cultures within which are filaments of different widths, while reisolated filaments of Types 2 and 3 give cultures which maintain their respective original widths.

All types may be induced to undergo lateral and occasional scalariform conjugation by introduction from soil water cultures to agar surfaces in light. The progressive disintegration of the male plastid into an orange carotenoid body in the mature zygospore has been followed. A successful method of germinating mature zygospores has been developed which thus enables study of width variation subsequent to germination. Experimental conditions have greatly reduced the time for one complete life cycle in as far as cells of 4-celled germlings still retained within the old zygospore cases have frequently been observed conjugating and forming new zygotes.

Cytological studies of mitoses and meioses are in progress in an attempt to explain some of the variations observed.

Genetic Control of Anthocyanin Synthesis in *Impatiens balsamina.* CHARLES W. HAGEN, JR., Indiana University, and RALPH E. ALSTON, College of William and Mary.—Anthocyanin pigmentation in *Impatiens balsamina* is controlled by genes at three independent loci. The aglycones of the anthocyanins and the anthocyanidin derivatives of the leuco-anthocyanins present in stems, colorless buds, and mature flower parts have been identified in plants of various genotypes. From these qualitative determinations, it is possible to draw certain conclusions as to the action of the individual genes.

With recessive alleles at the three loci, plants produce white flowers and green stems, but leuco-anthocyanins are present. The dominant gene, H, leads to more reduced pigments in mature flowers, but seems to act on the leuco-pigments of the colorless buds. L leads to more highly oxidized pigments in the mature flowers and probably acts on leuco-pigments. Genes L and H show no qualitative competition, the products of both genes being found in mature flowers of appropriate genotypes. Pr intensifies all flower colors, causes red pigmentation of the stems, and probably controls the conversion of leuco-pigments to free anthocyanins. It seems to shift the leuco-pigments present in the bud toward more reduced forms, but acts at a later stage of development than H. Methylation is intense in petals, less so in sepals, and absent in stems. Methylation is unaffected by the genes considered here except as they provide or remove pigments susceptible to methylation.

Flavonols and other unidentified yellow to orange pigments vary in different stocks of *Impatiens balsamina,* but are not qualitatively altered by the genes that regulate anthocyanin pigmentation.

Host Reaction to Infection by *Synchytrium australe.* JOHN S. KARLING, Purdue University.—The reaction of malvaceous hosts to injection by *Synchytrium australe* is manifested primarily by cell enlargement and division but not by cell differentiation. Infection by zoospores which develop into prosori results generally in cell division and enlargement of the host cell, but infection by potential or incipient resting spores usually causes only cell enlargement. The composite multicellular sporangial galls are derived from a single infected epidermal cell, and the healthy neighboring epidermal cells are only rarely if at all involved in normal gall development. The enlarged host cell begins to divide a few days after infection, cutting of tangential cells which in turn divide and grow around it to form the enveloping sheath of mature galls. The cells which are cut off first appear to get a head start in growth and division so that the sheath develops more rapidly over one surface of the host cell. As a result the mature galls become assymmetrical in shape with the aperture or pore to the infected cell in a subapical position. The nucleus of the infected cell may enlarge in proportion to the increase in size of the host cell, but it does not become distorted in shape or altered in fundamental structure. It may persist until the prosorus and sorus are mature. No marked increase in cytoplasm or accumulation of residue around the sorus occurs in the sporangial galls.

The resting spore galls are predominantly simple and unicellular. Accordingly, the host reaction consists primarily of enlargement of the infected epidermal cell, although cell division occasionally occurs to produce multicellular galls. In infected cells of *Modiola caroliniana* a marked increase in cytoplasm and residue occurs so that the host cell usually is filled with a reddish-brown material at maturity. In *Althaea rosea*, on the other hand, very little residue is present around the resting spores. In neither the sporangial nor resting spore galls has any marked thickening, lignification, or dissolution of the cell walls been observed.

A fairly large number of galls abort on various hosts, and this appears to be due to the death of the parasite. The infected cell eventually dies and may become invaginated by the adjacent healthy cells. In relatively resistant hosts like *Gossypium herbaceum* and *Circaea latifolia* infection of epidermal cells and their subsequent death may result in division of the palisade and mesophyll parenchyma whereby cushion- or dome-shaped protuberances are formed.

Host Range of and Reaction to *Synchytrium brownii* Karling. JAMES T. SINSKI, Purdue University.—*Synchytrium brownii* was found as a parasite of *Oenothera biennis* in the Ross Biological Reserve of Purdue University. In studies to determine its host range, it has been found to attack twenty-two races of *O. biennis*. The races in their respective groups include:

Group	*Race*
"biennis 1"	Belleville (Ill.)
	Birch Tree I (Missouri)
	Birch Tree II (Missouri)
	Birch Tree III (Missouri)
	Chicagoensis (Ill.)
	Iowa I
	Paducah (Ky.)
"biennis 2"	Elma (N. Y.)
	LaSalle III (N. Y.)
	Shulliana (N. J.)
	Waterbury (Vt.)
"biennis 3"	Newfound Gap (Tenn.)
"biennis ?"	Camas (Wash.)
grandiflora (?)	Grandiflora de Vries (Ala.)
"hookeri"	Franciscana de Vries
"Jamesii"	Parras (Mexico)
"parviflora"	Muricata (Europe and Pa.)
strigosa	Clarks (Nebr.)
	Cockerelli (Colo.)
	Fruitland (Idaho)
	Iowa II
	Spooner (Wis.)

In addition it may attack *O. laciniata* and *O. missouriensis*. No infection has been obtained on *Guara biennis* and *Circaea quadrisulata*, other species of the Onagraceae.

As the result of leaf infection, the host reacts to form either unicellular or multicellular galls on the majority of plants used. The unicellular galls consist of the enlarged epidermal cell which may project into or from the mesophyll. The multicellular galls consist of the enlarged epidermal cell plus cells surrounding it. The origin of these surrounding cells has not been determined.

Infections the same age as the above in the Paducah (Ky.) race produced notable results. Most galls were unicellular and greatly reduced in size. Around numerous infected cells a cell barrier filled with an unidentified deeply stained substance was found.

Resting Spore Germination in *Synchytrium* in Relation to Classification. B. T. LINGAPPA, Purdue University.—In the most recent key to the subgenera of *Synchytrium* the occurrence of summer and resting spores and their mode of germination are important criteria in the classification. In a study of the life-cycle of several of the long- and short-cycled species of *Synchytrium*, the author has succeeded in germinating the resting spores of 21 terrestrial species and from these results it is now possible to classify them in their proper subgenera. Among the long-cycled species studied, the resting spores of *S. rytzii*, *S. wurthii*, *S. collapsum*, *S. lepidagathidis*, *S. sesomicola*, *S. akshaiberi*, *S. brownii*, *S. nyctanthidis*, *S. zorniae*, *S. cassiae*, *S. oroxyli*, *S. maculans*, *S. launeae*, *S. crustatum*, *S. biophyti*, and *S. cookii* functioned as prosori in germination and because their summer spores also function as prosori in germination they may be assigned to the subgenus *Microsynchytrium*. Among the short-cycled species which produce only the resting spores, germination has been obtained in *S. thirumalachari*, *S. ajarekari*, *S. viticola*, *S. rhinchosiae*, and *S. meliloti*. Here also the resting spores functioned as prosori in germination and may now be placed in the subgenus *Pycnochytrium*.

Aberrations in Fungi of the Genus *Cyathus* and their phylogenetic Significance. HAROLD J. BRODIE, Indiana University.—A highly aberrant type of fruit body has been found to be developed in cultures of two tropical species of Bird's Nest Fungi, *Cyathus poeppigii* Tul. and *C. montagnei* Tul. Normal fruit bodies of these fungi are vase-shaped and contain a dozen lenticular peridioles provided with funiculi. Cultures of the aberrant forms produce small spherical fruit bodies each containing a single large spherical peridiole devoid of funiculus. Had the aberrant fruit bodies been found in nature it would be necessary to erect a new genus or even a new order of Gasteromycetes to accommodate them.

Tendencies to variation which might lead to the production of the aberrancies described have been noted in various species of *Cyathus*. Two of the most important of these are: the tendency for the production of very small fruit bodies accompanied by reduction in the number of peridoles, in the extreme situation to one; and the tendency for loss of the funiculus.

The various aberrancies are of considerable importance in interpreting phylogeny in the Nidulariaceae.

Antibiotics from the Mucorales. I. Preliminary Survey of 150 Species. BRINTON M. MILLER and C. L. PORTER, Purdue University.—A survey of the literature on antibiotic studies of the order Mucorales indicates only a few such studies with generally negative results. This paper deals with the preliminary work in a detailed investigation of the entire order for antibiotic producing properties. Results indicate that continued research with this group of microorganisms is warranted.

Preliminary Vitamin and Mineral Requirements of a Keratin Decomposing Fungus. FREDERICK M. ROTHWELL, Purdue University.—*Phlycto-*

rhiza variabilis, isolated from soil, is a rapid decomposer of keratinized tissue such as skin, hair, hoof and horn. Mineral requirements to date have been established for zinc, copper and iron. Zinc and copper in combination favor sporulation at a concentration of 0.05 ppm; at a concentration of 0.1 ppm vegetative growth is maximum and sporulation is minimum. Vitamin studies, while yet incomplete, indicate a requirement for biotin (0.3 ugm/ 50ml) and folic acid (3.0 ugm/ 50ml). To the knowledge of the author this is the first case of a fungus requiring folic acid. Further study is in progress to confirm this apparent requirement.

The Relationships of *Helianthus laetiflorus, H. rigidus,* and *H. subrhomboideus.* SARAH B. CLEVENGER, Indiana University.—The hexaploid species, *Helianthus laetiflorus, H. rigidus,* and *H. subrhomboideus,* on the basis of morphological characteristics were found to comprise an intergrading series with *H. subrhomboideus* as a relatively stable taxon at one extreme and with *H. rigidus* and *H. laetiflorus,* the other extreme, much more variable. It is suggested that the latter two species are the result of introgressive hybridization of *H. subrhomboideus* with another hexaploid species, probably *H. tuberosus.*

Testing the Line-Strip Sampling Method Against Full Tallies in Four Forest Types. ALTON A. LINDSEY, Purdue University.—The line-strip sampling unit is a combination of line interception and quadrat methods in which only the line is surveyed. The line-strip method is shown statistically to be suitable for detailed studies in three diverse types of eastern coniferous forests (spruce-fir, red pine-white pine, and jack pine) and in a maple-beech stand. This unit has several important advantages, in both field and office work, over the quadrat as usually applied. It is ideal for permanent marking of sampling units. Strip-quadrats (fractions of the strip) can be varied in length *a posteriori* to make frequency comparisons with publications based on quadrat sampling. Although the line-strip is no better for finding the nature of dispersal, the need for this is much reduced because of a statistical property of very long sample units. Usually about eight line-strips, each 600 ft. long, and covering at least 15 per cent of the station area, should be used to obtain an acceptable per cent standard error of 20 or less for each significant species. To obtain per cent sampling errors of similar amount for density, basal area, and cover, the strip width need not exceed 20 ft. for eastern coniferous stands, but should be 24 ft. wide for maple-beech. Basal area is much more accurately sampled in coniferous stands than in maple-beech. Although introduced for coniferous stands and easier to use there, the line-strip method appears to be well adapted to hardwood stands also, since only in the maple-beech stand were cover errors the lowest ones. The method is rapid considering the area sampled and the scope of data obtained, and is well suited for judging sampling adequacy by statistical procedures.

The Relationship Between the Age of the Tree and the Rooting of Cuttings in White Pine. ALBERT L. DELISLE, University of Notre Dame.—Further experiments have confirmed the observation that one of the most important factors in the vegetative propagation of white pine cuttings is the age of the tree from which the cuttings were taken. On one-year-old cuttings, rooting ability falls off in inverse proportion with increasing age of the tree. Although auxin treatment definitely increases the percentage and quality of rooting, it does not eliminate the effect of the age of the tree on the rooting of cuttings taken from it.

Experiments were undertaken to test the percentage of rooting of one-year-old cuttings taken from trees previously rooted by cuttings. The original cuttings, planted in 1938, were allowed to grow into 4-year-old saplings from which cuttings were taken in 1942. These rooted cuttings were allowed to grow into young trees until 1946 from which cuttings were again taken to test their rooting ability. This process was repeated in 1950 and 1954.

Results from these experiments indicated a marked decrease in rooting ability with each subsequent replication. Some saplings produced cones in 1953-54, indicating a transition to the reproductive stage.

It is postulated that a physiological age-factor affects the vegetative propagation of white pine.

An Interference Effect on Apparent Rates of Recombination in Regions Adjacent to Heterozygous Inversions. J. R. SINGLETON, Purdue University.—A simple mechanism is proposed to account for at least part of the increase in recombination frequency in regions adjacent to an inverted segment in inversion heterozygotes, such as have recently been observed in maize. This mechanism may be outlined as follows:

(a) Depending upon the intensity of interference between the inverted segment and a segment adjacent to it, chromatids which are crossovers in the adjacent segment will tend not to be crossovers in the inverted segment, and vice-versa.

(b) Chromatids which are single crossovers in the inverted segment will be eliminated, and will not be represented in the population of recovered meiotic products in which recombination is measured.

(c) Since the eliminated chromatids will tend to be non-crossovers in the adjacent segment, the proportion of chromatids which are crossovers for this region will be higher in the population of recovered meiotic products than in the initial population. The net effect will be an increase in the rate of recombination observed for the adjacent segment over the actual rate of crossing-over at meiosis.

Since several factors will affect the meiotic rate of crossing-over, one can, at best, estimate only the maximum observable increase which such a mechanism might cause. Simple algebraic formulations have been developed to give this estimate for varying levels of interference and crossing-over in various types of inversions. These indicate that an increase may be expected with pericentric inversions, and with paracentric inversions in the male. In females of the *Drosophila* ordered-tetrad type, paracentric inversions may result in an apparent decrease through this mechanism.

The Lyophilization of Some Algae. W. A. DAILY and J. M. MCGUIRE, The Lilly Research Laboratories.—The lyophile process was investigated as a means of preserving in a desiccated state 32 cultures of algae. Seventy-five per cent survived lyophilization. These remain on periodic viability tests, and when cultured recently at from four to ten months after lyophilization they were still viable.

Response of Spring Wheats to Photoperiod and Temperature. GEORGE A. GRIES and FOREST STEARNS, Purdue University.—Spring wheats were grown at all combinations of day and night temperatures of 60° F., 70° F. and 80° F. under both 12- and 16-hour photoperiods. In the 12-hour series earliness was associated with cool temperatures while in the 16-hour series it was associated with warm temperatures. The experimental data indicate that although both day and night temperatures are important in eliciting these responses, night temperature is the more critical. Some evidence is available to indicate that cool temperatures and long days are conducive to induction of flower primordia and that warm temperatures and long days are most favorable for maturation. On this evidence it may be assumed that plants grown at 16 hours are induced early regardless of temperature so that the influence of temperature on maturation becomes critical in determining date of maturity. In the case of the 12-hour photoperiod series it is assumed that those plants at the cool temperatures are induced so much earlier that they mature at an earlier date in spite of the relatively unfavorable temperature for maturation.

Selectivity in Indiana Mosses

WINONA H. WELCH, DePauw University

Mosses, in a general sense, grow in a great variety of situations, as for example, *Amblystegium varium*, in moist shaded places, on soil, at base of trees, on decaying wood, and on rock. Mosses characteristically grow in moist shaded habitats although they do occur in dry exposed situations and in water. Common substrata are rocks, soil, bark of living and dead trees and shrubs, and decaying organic matter. However, many species are very selective in choice of habitats. Because of this selectivity, several mosses may be regarded as plant indicators of certain conditions of the substratum. Upon approaching a specific habitat, a bryologist searches for certain species or genera of mosses. And, conversely, certain species and genera of mosses are often indicators of specific substrata and habitats.

Since mosses have no roots, they are frequently quite dependent upon atmospheric moisture. The mosses are usually more shade-tolerant than the more highly developed plants, although some prefer full sunlight. In shade, there is more moisture in the atmosphere and a reduced rate of transpiration from the plant and evaporation from the substratum. Those living in the sun are tolerant of high rates of transpiration and evaporation, low humidity, and higher temperature.

Some mosses prefer habitats such as lakes, pools, ponds, swamps, bogs, and slow rivers, while others choose swiftly flowing streams. The rate of movement of the water influences the amount of mechanical action and affects the aeration of the water.

The response of mosses to edaphic factors is usually quite distinct. Some of the common preferences in Indiana are rock, humus, bark, bare soil, bogs, and swamps. Other species are more particular and require certain kinds of rock, soil, and humus. In preparation of data for this paper, species have been omitted if they usually grow on more than one kind of substratum; e.g., on rocks, soil, and bark. An attempt has been made to include only those species of mosses known to grow in Indiana, which appear to be selective or specific in habitat or substratum, and thus may be regarded, frequently, as plant indicators of specific conditions.

Knowledge of the genera and species of mosses frequently aids in a speedy and general recognition of the acidity or alkalinity of a substratum. All species of *Sphagnum* and some species of *Polytrichum* avoid the slightest traces of lime, and *Hypnum molluscum* has a definite preference for alkalinity, at least a slightly alkaline substratum. *Cratoneuron filicinum* thrives in water, especially occurring in springs and rivulets, preferring those which have a pH above neutral. *Campylium stellatum* and *Drepanocladus aduncus* either prefer or are tolerant of fens (alkaline bogs). *Gymnostomum* appears to be an obligate calciphile, *G. calcareum* occurring on damp ledges of limestone and *G. recurvirostrum* on dripping ledges. *Grimmia apocarpa* is calcicolous, selecting the horizontal surface of more or less flattened rocks, either in sun or shade. *Didymodon tophaceus* grows in calcareous habitats, on wet soil and cliffs and in springs and brooks, and is regarded as important in the building of tufa.

Other Indiana mosses which are usually calcicolous or calciphiles (normally growing on calcareous substrata) are *Amblystegiella confervoides, A. minutissima, Barbula unguiculata, Desmatodon obtusifolius, D. Porteri, Didymodon trifarius, Myurella Careyana, Orthotrichum strangulatum, Rhytidium rugosum, Thuidium pygmaeum,* and *Tortula ruralis. Thuidium recognitum* occurs in limestone regions, but not necessarily on stone as it also occurs on soil and rotten wood.

Moss species may be recorded as calcicoles because they occur in a calcareous area and appear to be growing on limestone, when actually the plants are growing on a layer of acid humus on the stone or on the upper portion of the limestone which has a pH reading below neutral as the result of leaching. Thus, these plants may be calcifugous (not normally growing on calcareous soils) instead of calcicolous. On the contrary, a collection of moss plants on sandstone may be recorded erroneously as calcifugous. Often sandstone contains lime compounds. Without tests, one may not be aware of this condition, but calcicolous mosses on sandstone are regarded as excellent indicators of the presence of the calcareous inclusions; e.g., *Desmatodon Porteri.*

Many mosses grow only on rock. Some prefer the surface, others grow in the crevices; some choose calcareous rock, others non-calcareous; some like moist shaded habitats, and others the full sunshine. Although the records report rock as the substratum, there is a sufficient supply of humus available on the rock for the growth of the moss. *Porotrichum alleghaniense, Amblystegiella minutissima,* and *Bryoxiphium norvegicum* occur in moist shaded ravines, the *Porotrichum* on damp rock near streams, the *Amblystegiella* preferring limestone, and the *Bryoxiphium* the almost vertical faces of sandstone. Indiana crevice-mosses are *Fissidens Closteri,* preferring decomposing rocks, *Myurella Careyana, Plagiothecium Muellerianum,* and *P. elegans.* The mosses in the state which especially like dripping ledges are *Gymnostomum recurvirostrum,* a calciphile, and *Hookeria acutifolia,* which has the westward limit of its known distribution in Indiana, on the surface of sandstone forming almost vertical sides of canyons. Since the latter moss also grows near cool springs and on stream banks, it is apparent that an abundance of moisture is one of its habitat requirements.

Mosses in Indiana which grow specifically on shaded and somewhat moist to very damp rocks include *Dicranum fulvum, Fissidens exiguus, F. minutulus, Hyophila tortula,* and *Sematophyllum carolinianum;* on wet rocks, *Mnium marginatum* and *M. punctatum;* and on rock and stones in brooks or streams, possibly submerged at times, *Brachythecium flagellare, B. rivulare, Fissidens obtusifolius, Grimmia apocarpa* var. *alpicola, Hygroamblystegium irriguum, H. orthocladon,* and *Hygrohypnum palustre.* It is apparent that these mosses not only select rock substratum but are also able to distinguish, in a general sense, between the different amounts of water on the rock which seem to be optimum for their growth.

Although the majority of mosses grow on moist shaded substrata, some species are known to grow only on dry rocks in full sunshine; e.g., *Grimmia apocarpa* and var. *conferta*, and *G. pilifera.* Those preferring exposed non-calcareous substratum are *Grimmia laevigata, G. Olneyi, Hedwigia ciliata,* and *Ulota americana.* Others select silicious rock in the open, as *Ptychomitrium incurvum,* or somewhat calcareous rock, as *Rhytidium rugosum.*

Many mosses in the state use soil for their specific substratum. We may regard soil as a mixture of weathered or disintegrated rock and varying amounts of organic material. The soil mosses are particular in several instances as to the kind and/or condition of the soil, whether it is shaded or exposed to full sunlight, moist or dry, recently disturbed or undisturbed for a long period, poor or rich in organic substances, sand or clay, etc.

Bryum caespiticium may be regarded as an indicator of poor soil or one not rich in organic matter. On the contrary, *Aulacomnium heterostichum,* a moss of the woods, is indicative of soil rich in humus. In old fields, in the open and yet partially shaded by taller plants and on soil more or less smooth because of lack of cultivation, *Astomum Muhlenbergianum, Bruchia Sullivanti, Ditrichum pusillum, Phascum cuspidatum* var. *americanum,* and *Weisia microstoma* find their favorite habitat. Those that thrive on soil which is periodically disturbed are *Barbula unguiculata, Ephemerum serratum, E. spinulosum, Leptobryum pyriforme,* and *Weisia viridula.* These plants are short, 1-20 mm. high, and the soil of fields, roadside banks, and paths makes it possible for them to pioneer with little competition. The disturbed soil provides numerous pockets for catching the wind blown spores and sufficient moisture for the germination of the spores. Others choose clayey soil, as *Aphanorhegma serratum, Atrichum undulatum,* and var. *altecristatum. Dicranella varia* and *Ditrichum pusillum* prefer to grow on freshly exposed clay, where they may be regarded as pioneers and where competition with other plants is nil. *Anomodon rostratus* occurs on soil at base of trees, cliffs, or rocks, having a somewhat wet habitat as water runs down these structures into the soil where it is retained in accumulated humus. Other species thrive on the soil of lawns, between grass plants and weeds, and thus are provided with humus and shade. Here we frequently find *Atrichum angustatum, Leptodictyum brevipes,* and *Physcomitrium turbinatum,* and occasionally *Pleuridium subulatum. Dicranum condensatum* and *Ditrichum pallidum* thrive on dry sandy soil, which would seem to indicate that they do not need much humus for holding water or as a source of food materials. Other mosses occurring on sandy soil are *Atrichum angustatum* and *Bryum bicolor. Philonotis fontana* and varieties *falcata* and *pumila* and *P. marchica* live on very wet soil. *Mnium medium* likes wet ground in woods. Indiana mosses which prefer moist shaded soil are *Atrichum undulatum, Eurhynchium hians, Fissidens bryoides, F. osmundioides, F. taxifolius, Mnium cuspidatum, Plagiothecium geophilum, P. Roeseanum,* and *Polytrichum commune. Polytrichum juniperinum* grows on soil, usually exposed to the sun, but sometimes in the shade.

One of the common mosses, not only in Indiana but all over the world, is *Ceratodon purpureus.* It prefers barren habitats whether the substratum is soil, burned area, rock, sand, or an old roof. Thus it is tolerant of exposed or open habitats with small amount of humus and moisture, and is able to grow as a dense sod of moss, often with little competition with other plants.

Upon moist banks or roadsides where the soil has been recently disturbed, *Pogonatum brachyphyllum* or *P. pensilvanicum* grow abundantly before other plants establish themselves. These mosses have an abundant, conspicuous, and persistent protonema. Such soil is frequently covered with the thin layer of perennial protonema and attracts one's attention at some distance because of the beautiful yellow-green mass of filaments. The stems of these mosses are short (1-3 mm.). The leaves are also small and are erect or erect-spreading. Only by close examination are these portions of the gametophyte evident in the field. The sporophytes are conspicuous and abundant. These mosses cover the freshly disturbed earth before their plant competitors are able to develop. The persistent protonema is not only important to the plant as it apparently carries on considerable photosynthetic activity, but also to man, as it seems to be very effective in preventing or retarding surface erosion of clayey banks. *Buxbaumia aphylla*, a moss of open woods, also has protonema on surface of barren soil. These green filaments carry on photosynthesis for the moss as the leaves are so minute that they are almost obsolete. Other Indiana mosses which select to live on damp clayey or silty banks, usually shaded, are *Aphanorhegma serratum*, *Barbula fallax*, *Dicranella heteromalla*, *Ephemerum serratum*, and *E. spinulosum*.

Humus is a required substratum for some bryophytes. Mosses which grow on rock really have sufficient supply of humus available although it may not be evident to the collector until after careful examination of the substrate. In some parts of the United States and Canada there are mosses which are obligately nitrophilous. No moss in Indiana is now known to live on a specific nitrogen-rich substratum. Richards suggests that *Bryum argenteum* is probably nitrophilous. This *Bryum* is a common Indiana species. *Buxbaumia aphylla* and *Mnium stellare* prefer moist shaded places, especially woods, and grow on a substratum of humus.

The habitat recorded in the manuals for *Tetraphis pellucida* is humus and decaying wood in cool, moist, shaded places. In Indiana, *Tetraphis pellucida* is a common plant on distinctly different habitats which appear to have something in common that is favorable for the growth of this moss. It occurs in moist shaded places on either sandstone or on decaying wood, or on peaty banks of streams. Apparently it seeks a habitat rich in organic matter. If humus is present on sandstone or in accumulated soil on the stone, *Tetraphis pellucida* is able to grow there as well as on decaying wood. Dr. Conard, in Vegetation of Iowa, regards water supply as the factor in common in rotten wood and in porous sandstone, since both habitats contain sufficient moisture and can supply the plants with water easily. It seems to the writer that it may be a combination of a ready source of water and sufficient organic matter that provides the favorable habitat. Another moss in Indiana which seems to prefer rotten wood but can also thrive as well on peaty banks is *Dicranum flagellare*. Grout, in Mosses with a Hand-lens, referred to *Tetraphis pellucida* and *Dicranum flagellare* as saprophytes, but not to the extent that they could survive without chlorophyll. Additional Indiana mosses which grow chiefly on decaying or rotten wood are *Hypnum imponens* and *Heterophyllium Haldanianum.*

At or near the base of some tree trunks one frequently finds abundant growth of moss. Apparently this habitat is more moist than the upper bark because the water draining from the upper portion of the trunk accumulates in the basal area. Some kinds of mosses grow above the base for a distance of a few feet, others occur throughout the surface of the trunk as well as on the branches, and others prefer only the basal portion of the tree because of the accumulation of humus. The bark of deciduous trees seems to be preferable as mosses do not commonly grow on trunks of coniferous trees. The lack of epiphytic mosses on birch and pine trees may be due to the continued peeling and scaling of the bark. Corticolous mosses (epiphytes) in Indiana include *Chamberlainia acuminata, C. cyrtophylla, Clasmatodon parvulus, Drummondia prorepens, Entodon compressus, Homalotheciella subcapillata, Leucodon brachypus, L. julaceus, Lindbergia brachyptera* var. *Austinii, Orthotrichum obtusifolium, O. ohioense, O. pumilum, O. pusillum, O. sordidum, O. stellatum, Platygyrium repens, Pylaisia intricata, P. Selwynii, Thelia asprella, T. hirtella, Tortula pagorum,* and *Ulota crispa. Orthotrichum* spp. are most frequent on trees about houses, in orchards, and on village streets, but they occur elsewhere where trees are somewhat apart. They prefer fruit and shade trees in country towns rather than in cities. According to Grout, *O. stellatum* grows especially on apple and butternut tree trunks. The species of *Orthotrichum* and *Pylaisia* prefer an atmosphere with high humidity. *Dicranum viride* grows on either living trees or decaying logs. Epiphytic mosses are very sensitive indicators of an atmosphere without any noticeable amount of smoke or gas.

The age of the host tree is important to the moss plants because the older trees have a thicker and rougher bark and thus retain more water for the bryophytic epiphytes and increase the deposition of dust and accumulation of humus. Pessin (Ecol. 6: 17-38. 1925) presents evidence that there is nitrogen in the humus of the bark and minerals in the dust from the air.

One of the most interesting mosses in Indiana is *Anacamptodon splachnoides.* Because of its unusual habitat in knotholes of deciduous living trees, it has been given the name of "the knothole moss." In these cavities it has a substratum of decaying wood soaked with water during portions of the year.

Upon approaching burned areas in Indiana, whether in the woods or in the open, the anticipation of finding *Funaria hygrometrica* and/or *F. flavicans* is usually realized, providing sufficient time has elapsed since the fire. *Leptobryum pyriforme* and *Bryum argenteum* may also occur in such habitat. *Funaria* is a very reliable indicator of a place in which there has been a fire. Even if the cinders or charcoal are not evident on the surface, fragments may be found in the soil. One assumes that *Funaria* has a strong preference for moist carbon, but this moss sometimes grows in rock crevices, and also occurs on limestone, mortar, and plaster, suggesting that it requires a porous habitat with good drainage. Hesselman

(Medd. fron Statens Skogsförsöksanst. Hfte. 13-14, Bd. 2, 1916-1917, pp. ci-cv of the English summary) has given evidence that a sudden great increase in nitrifying power results from the burning of raw humus soils. Herzog (Geographie der Moose, Jena, 1926, p. 69) suggested that some of these mosses of burnt ground may be nitrophilous. Richards adds to these possibilities the suggestion that these species may prefer high concentrations of potassium or of mineral salts.

Numerous moss species select habitats with considerable moisture in the substratum or choose to live in water a portion of or throughout the year. Swamps, ponds, lakes, streams, springs, and spray from waterfalls satisfy this water requirement. Some of the mosses live in the water and others choose the margins or close proximity to the water. Indiana species which occur in these subaquatic or aquatic habitats include *Aulacomnium palustre, Brachythecium flagellare, B. rivulare, Calliergon cordifolium, Campylium polygamum, C. stellatum, Climacium Kindbergii, Cratoneuron filicinum* (preferring those containing lime), *Dichelyma capillaceum, Drepanocladus exannulatus* f. *orthophyllus, D. vernicosus, Fissidens julianus, F. obtusifolius, Fontinalis biformis, F. dalecarlica, F. disticha, F. Duriaei, F. novae-angliae, F. novae-angliae* var. *latifolia, Helodium paludosum, H. paludosum* var. *helodioides, Hygroamblystegium fluviatile, H. irriguum, H. irriguum* var. *spinifolium, Hypnum Patientiae, Leptodictyum riparium* and forms *fluitans, longifolium,* and *obtusum, Mnium affine, Philonotis fontana* and vars. *falcata* and *pumila, P. marchica,* and *Pohlia Wahlenbergii.*

Mosses which usually grow on wet, spongy earth containing quantities of decaying moss and other vegetable matter (bogs and fens) are *Aulacomnium palustre, Campylium stellatum, Helodium paludosum, H. paludosum* var. *helodioides, Polytrichum juniperinum* var. *alpestre, Sphagnum capillaceum, S. compactum, S. fimbriatum, S. Girgensohnii, S. imbricatum* var. *affine, S. magellanicum, S. palustre, S. recurvum, S. recurvum* var. *tenue, and S. subsecundum. Campylium stellatum* is a characteristic moss of both bogs (acid) and fens (alkaline), so it may be assumed that the wet organic matter rather than the pH factor is the determining habitat condition in the case of this moss. *Drepanocladus aduncus* is an associate of *Campylium stellatum* in the fens. The other species may be regarded as indicators of an acid substratum.

Some species of mosses prefer to grow in a layer of soil which has collected on stone or brick walls or on soil between buildings and walks or on soil between bricks, stones, or segments of concrete in walks. *Bryum argenteum* is one of the most common mosses in this kind of habitat. It has also been collected on roofs.

An interesting observation is that species within the same genus are very selective with regard to their habitats. The following mosses will illustrate this condition in Indiana. *Amblystegiella subtilis* on bark and *A. confervoides* on limestone rocks; *Dicranum flagellare* on rotten wood and *D. fulvum* on rock; *Orthotrichum anomalum* on rock and *Orthotrichum* spp. on bark; *Aulacomnium heterostichum* on moist rich soil in woods and *A. palustre* in swamps and wet shaded hollows; *Drepanocladus aduncus* in calcareous waters or wet meadows and *D. exannulatus* in non-calcareous waters or swamps; *Leptodictyum riparium* f. *fluitans* and f. *longifolium* in water of springs or pools and *L. brevipes* on soil of shaded lawns; *Climacium americanum* on soil in woods and *C. Kindbergii* in wet places or in water; *Grimmia apocarpa* var. *alpicola* on rock in or close to streams and *Grimmia* spp. on dry rock; and *Thelia asprella* and *T. hirtella* on bark and *T. Lescurii* on sand or rock.

The ability of many Indiana mosses to select specific habitats seems evident. It is more difficult to discover all of the controlling factors in each instance of selectivity than to observe the choice of substrata. Because of these conditions, the data on herbarium labels are frequently inadequate and sometimes incorrect (especially as to sandstone and calcareous sandstone). Often, in the correct determination of moss species, specific knowledge regarding the substratum and habitat is helpful.

Acknowledgments

The writer is deeply indebted to H. S. Conard, Director of the Moss Clinic of the Iowa Lakeside Laboratory for counsel in regard to the determination of mosses as associated with specific habitats and substrata, to the State University of Iowa for a series of Honoraria which made possible the summers in research at Lakeside, to the Indiana Academy of Science for grants which made possible the collecting of the mosses throughout the state, and to the Graduate Council of DePauw University for research grants for use in study of Indiana mosses in herbaria in other institutions.

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Recent Collections of Pennsylvanian Plant Fossils in Indiana[1]

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Combined with other geological criteria, animal fossils, particularly marine invertebrates, have long been used for the correlation of many Paleozoic stratigraphic sequences. This method frequently demonstrates a remarkable degree of precision in the delimitation of strata. However, the paucity of animal fossils in the majority of the non-marine sedimentary rocks in the Pennsylvanian system creates a situation in which the stratigrapher becomes more or less dependent upon the use of plant fossils as indices. As a consequence, paleobotanical investigations of Pennsylvanian age rocks are often of considerable importance in correlation studies by showing the relationships of the coal seams of various coal basins. Although this is no less true of Indiana than of other coal-producing states, the stratigraphic significance of plant fossils in Indiana has thus far not been adequately tested due to a lack of knowledge of this state's Carboniferous flora. Because of this deficiency, it has not been possible to apply the nine Pennsylvanian floral zones proposed by Read (3) to the coal-bearing formations of Indiana.

Aside from the purely stratigraphic aspects, coal flora research contributes: (1) valuable information concerning the floristic composition of the ancient coal-forming forests and its relationship to the properties of various coals; (2) data which add to our knowledge of phylogeny through anatomical and morphological studies; and (3) evidence of the nature of Paleozoic climates.

In 1953, the junior author and J. M. Wood initiated a survey of the plants of the Pennsylvanian system in Indiana under the auspices of the Indiana Geological Survey (5). Twenty-three counties in the southern and western part of the state were covered, with collections being made at sixty of the one hundred and seventy-three sites visited (Fig. 1). The project was continued in 1954 by the present authors, who visited fifteen counties in southwestern Indiana, making collections at forty-eight of one hundred and thirty-seven locations (Fig. 1). Many of these locations were along the Pennsylvanian-Mississippian unconformity in Dubois, Greene, Martin, and Perry Counties. This is an area of particular stratigraphic interest, since the coals found there (termed the Pottsville coals) are near the base of the Pennsylvanian system. As a consequence, the plant fossils found in association with these coals are valuable indices in the correlation of the Eastern Interior Coal Basin (of which Indiana is a part, together with Illinois and western Kentucky) with the other coal basins of the eastern and midwestern United States. David White (4) made the first valid correlation of the Pottsville series of the Eastern Interior Coal Basin with strata in the Appalachian coal basin by means of seven species of fossil plants from the Hindostan whetstone beds of

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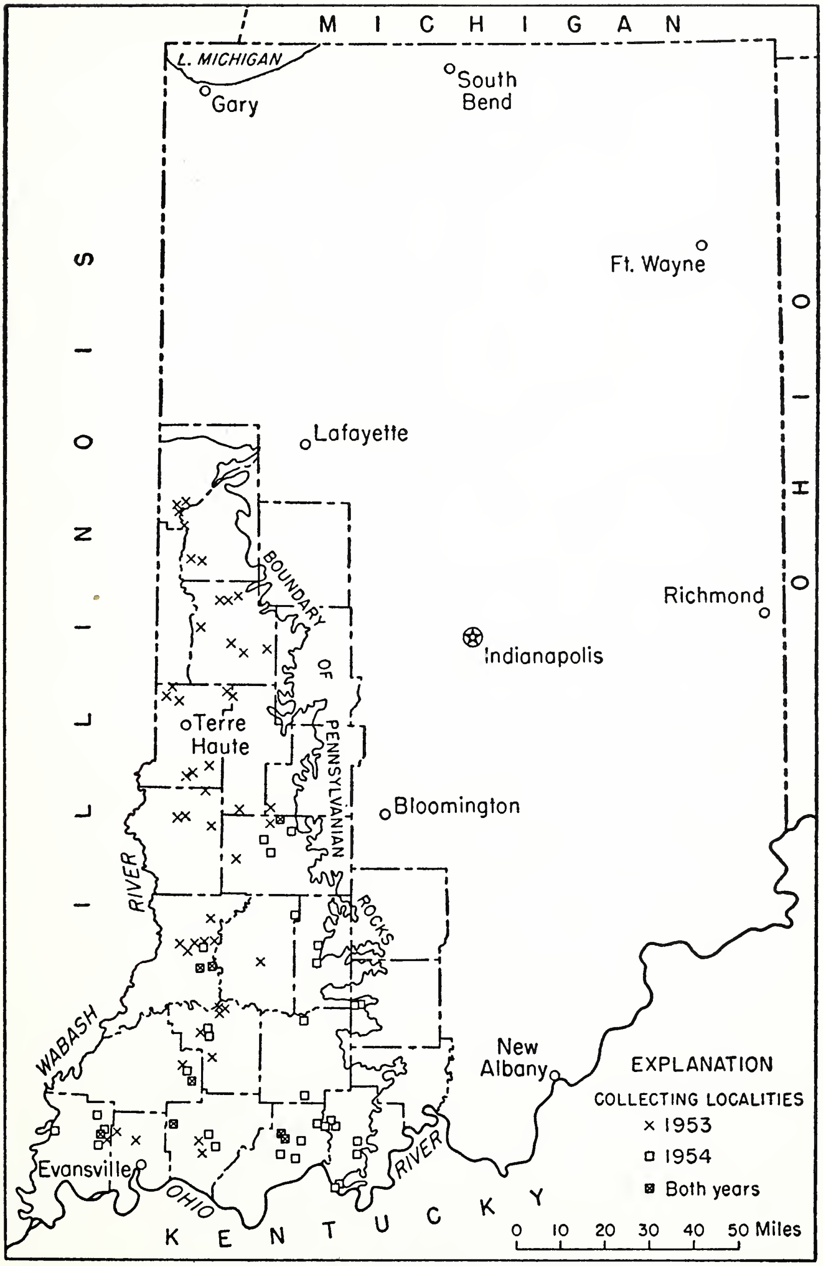

Fig. 1. Outline map showing the eastern boundary of the Pennsylvanian system in Indiana, and the more important sites investigated in 1953 and 1954.

Orange County, Indiana. Continued study of the fossil flora of these strata, as well as other similarly disjunct beds of the Pottsville series, should yield significant correlative data. This is particularly true in the case of the Pottsville coals, since they are found in pockets or lenses, rather than continuous seams, a factor which contributes to the difficulty of their correlation.

Two of the more interesting locations in the region of the unconformity are the abandoned Braxton and Daugherty whetstone quarries west of French Lick in Orange County. Good quality whetstones were manufactured from the fine-grained sandstone from these quarries beginning in the 1870's, although neither is producing at present. The presence of numerous upright *(in situ)* fossil tree trunks *(Lepidodendron)* in the Daugherty Quarry is reported to be one of the major reasons for its abandonment (2). From these whetstone beds the authors collected large quantities of irregularly bedded compressions of *Mariopteris pottsvillea* D. White. Other plants that have been obtained from this region are: *Sphenopteris hoeninghausii* Brogn., *Neuropteris biformis* Lx., *Lepidodendron veltheimianum* (?) *Sternb.*, *Lepidostrobus* sp. Brogn., and *Asterophyllites charaeformis* Sternb. This floral assemblage clearly indicates the pottsvillean age of these beds.

Near Dover Hill, a village in the center of Martin County, the authors chanced upon two sandstone *Lepidodendron* trunk casts being used as ornamental posts at the end of a farmhouse walk. On inquiry it was learned that the casts had been found on the Victor Sims farm (SE¼ NW¼, sec. 35, T.4N., R.4W.). These casts were between two and three feet long, and a third, examined *in situ* near a coal outcrop on the Sims property, was nearly four feet. Two other large casts had been removed previously by Sims. However, most of the external layers of these trunks had been lost, either during the process of fossilization or by later erosion, so that identification as to species was unreliable.

A collecting site of historical interest was the "Old Dam Site" (SW¼ SW¼, sec. 11, T.5S., R.14W.) at the lower end of the Wabash River Cutoff about three miles southwest of New Harmony in Posey County. This was an area in which some of the early geologists and paleobotanists such as J. Sampson, E. T. Cox, Leo Lesquereux, and the Owen brothers, David and Richard, made some of their collections during the latter half of the 19th century. A small portion of some of these collections can still be seen in the Museum of the Workingman's Institute in New Harmony. Unfortunately, the majority of the Owen collections, deposited at Indiana University, were destroyed by fire. Since the plant fossils at the Wabash Cutoff occur in a clayey shale between thin coal seams at the river edge, collections can be made only during periods of low water. Some of the most numerous species found there by the authors are: *Annularia sphenophylloides* Zenker, *Calamites cistiiformis* (?) Stur, *Sphenophyllum emarginatum* Brogn., *Neuropteris scheuchzeri* Hoff., *Sphenopteris elegans* Brogn., and *Mixoneura* cf. *sarana* Bertr.

Four additional coal ball sites were discovered in Indiana during the last field season, making a total of eighteen sites located during the past two summers. These calcified or partially pyritized aggregations of petrified plant remains are now known to occur in at least three coals in Indiana: (1) the Buffaloville coal, a localized lens in Spencer County that lies near the top of the Pottsville series; (2) Coal V, one of the more commercially important coal seams in the Allegheny series; and (3) the Parker's coal of Posey County near the top of the Pennsylvanian system in the Conemaugh series (Fig. 2).

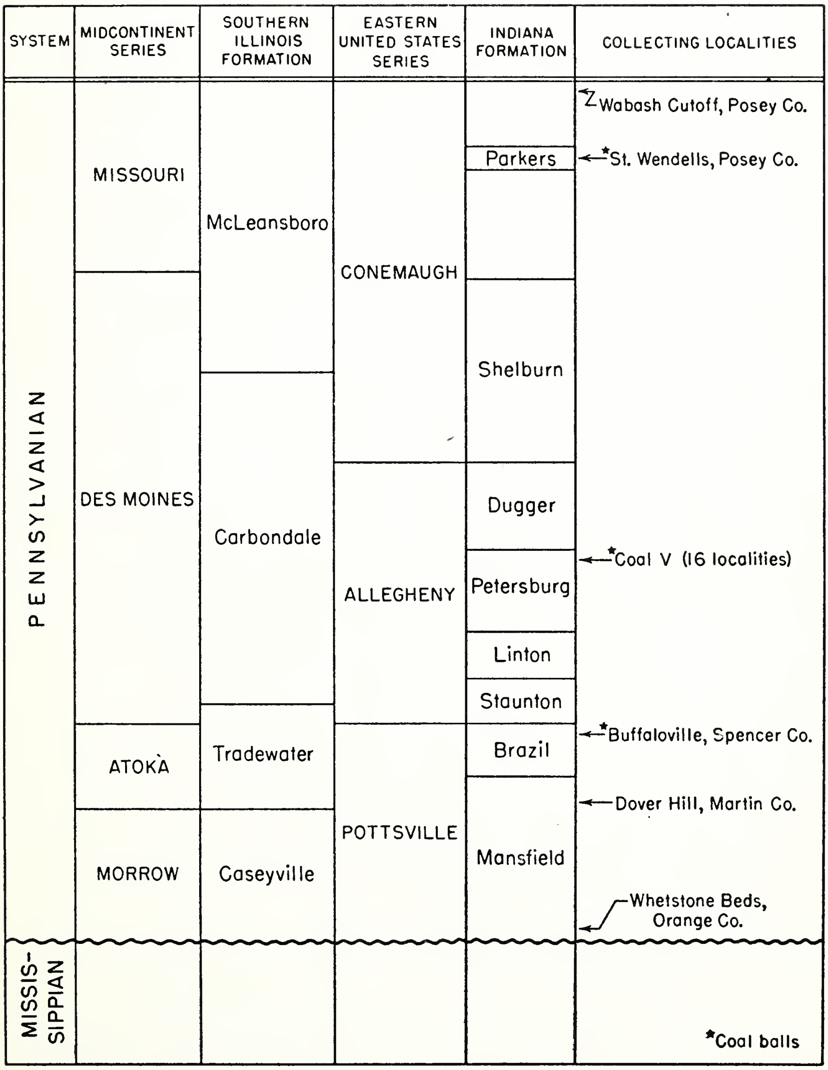

Fig. 2. Chart showing the stratigraphic positions of the collecting sites cited in the text, and correlations with three major coal-producing regions. A star indicates coal ball collections.

The plant fossils collected during the two-year span of this project, together with a few earlier collections, are deposited in the Coal Section of the Indiana Geological Survey. This assemblage is accessioned and cross-indexed by number and scientific name, and includes over 575 trays of specimens. All of these specimens have been identified to genus and more than two-thirds to species. To date, sixty-seven genera and one hundred and fifteen species have been determined, the great majority of which have not been reported previously from Indiana. This total does not include species identified from coal ball material.

The large number of fossil plant species collected during the course of this survey, which hitherto were not known to occur in this state, clearly indicates the need for the publication of a Pennsylvanian flora of Indiana (1).

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Response of the Fern *Woodsia obtusa* (Spreng.) Torr. to Temperature and Day Length

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Introduction and Methods

Mosses, liverworts, and ferns offer an excellent opportunity to study the influence of environmental factors as they effect both the sporophytic and gametophytic generations. To date most investigations have dealt with flowering plants, bacteria, fungi, or algae (Audus, 1953). Studies on the influence of temperature and photoperiod on mosses and ferns are presently in progress using the controlled climate facilities provided in the new Plant and Soil Laboratory at Purdue University. This report includes the results of a preliminary study involving the sporophyte of the fern *Woodsia obtusa* (Spreng.) Torr.

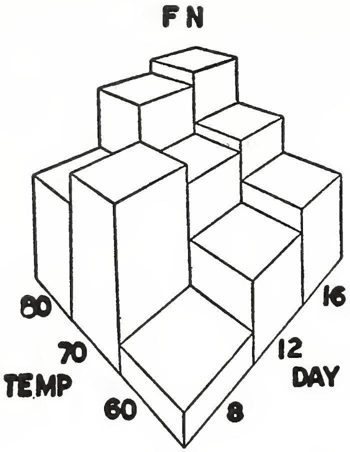
Rhizomes of the fern *Woodsia obtusa* (Spreng.) Torr. obtained near Lafayette, Indiana, on May 1, 1954 were transplanted to flats which were then placed under controlled conditions. These consisted of all possible combinations of 60°F., 70°F., 80°F. temperatures with 8 hr., 12 hr., and 16 hr. photoperiods. Fronds were clipped back in all flats on May 22nd. The plants were then allowed to continue growth under controlled conditions until August 6th, at which time fronds were again clipped and the following observations made: The total number of fronds per treatment; the total weight of fronds per treatment; the percentage of mature fronds bearing spores; the percentage of immature fronds bearing spores, the relative number of sori per frond. Numerical data are presented in Table I.

Results and Discussion

Frond number—The number of fronds produced appeared to be influenced by both light and temperature. The greatest number of fronds were observed under the 80°-16 hr. light treatment (fig. 1). Production dropped off progressively with decreasing temperature and decreasing day length.

Total dry weight of fronds—The dry weight of fronds seemed to be more closely correlated to light than to temperature (fig. 2). The dry weight of the fronds grown under 80°-16 hr. treatment was greater than under any other condition. Progressive decrease in weight accompanied decrease in day length for each temperature treatment but only slight variation occurred with variation of temperature in the day length series.

Mature fronds with sori—The percentage of mature fronds bearing sori decreased with decreasing day length (fig. 3). Variation in temperature did not appreciably influence the number of fronds bearing sori. However, the plants in these experiments may have retained some of their earlier induction from the field. Some substantiation of this is provided by data on immature fronds bearing sori. The percentage of immature fronds bearing sori (fig. 4) displayed a closer relation to day length. Experiments now in progress in which the plants have been subjected to 3 weeks of near 0°F. and then returned to controlled temperature and light conditions show abundant production of sori at 16 hour days, little at 12 hour days, and none at 8 hour days.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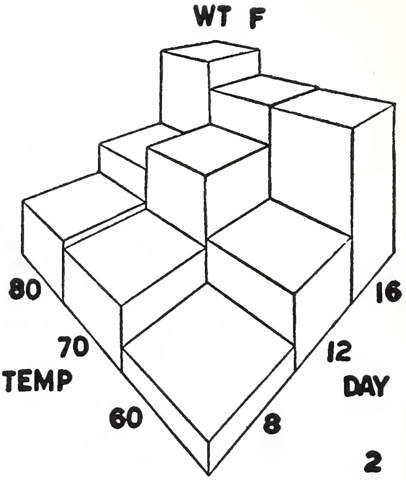
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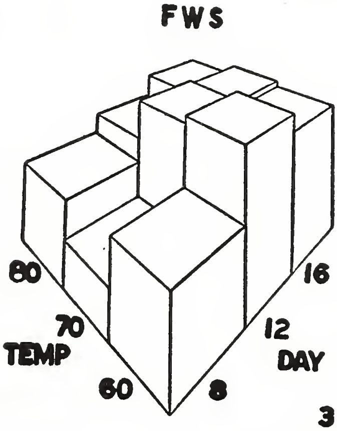
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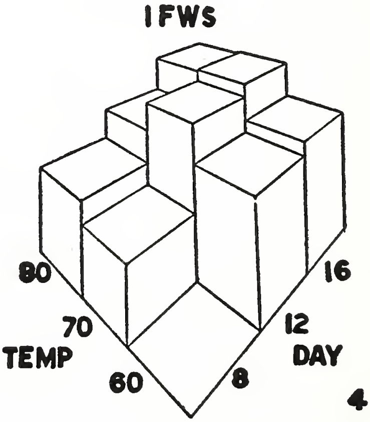
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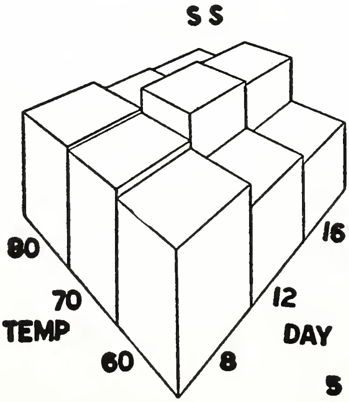
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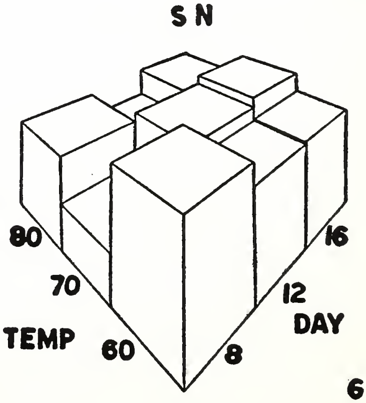
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Sorus size—The relative size of the individual sorus (fig. 5) declined slightly with increasing day length. Temperature apparently had no influence.

Sori number per frond—The relative number of sori per frond (fig. 6) varied among treatments with no evident correlation with either temperature or day length. This suggests that induction is a qualitative and not a quantitative mechanism insofar as the individual frond is concerned.

Natural production of sori in *Woodsia obtusa* occurs in mid-summer (Tryon et al. 1940), further evidence that this fern is a long day plant.

TABLE I

Observations on growth and sporulation in *Woodsia obtusa* (Spreng.) Torr. grown under controlled climate conditions.

Day length in hrs.	Temp. F.°	No. of fronds	Dry wt. of fronds (gms.)	% of mature fronds with sori	% immature fronds with sori	Sorus size value (0-10)[1]	Sori number per frond values (0-10)[1]
16	60	51	10.1	80.5	73.6	4.6	6.1
12	60	39	3.7	90.0	66.7	4.9	6.0
8	60	14	1.3	50.0	0.0	6.1	7.1
16	70	76	10.4	84.0	96.1	7.9	7.3
12	70	70	7.7	86.1	88.8	8.1	6.8
8	70	80	3.3	25.0	38.4	6.5	2.6
16	80	114	13.0	78.7	94.7	6.0	5.8
12	80	103	6.1	63.7	71.1	6.0	4.2
8	80	64	3.6	48.7	52.1	6.7	5.4

1. Arbitrary values established by visual estimation.

Summary

Woodsia obtusa (Spreng.) was studied under controlled conditions of temperature and day length. It was found that both factors influence the total number of fronds produced while the dry weight is more directly

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Explanation of Figures

General:	Figures are three dimensional graphs showing the influence of temperature and day length in different combinations. Refer to Table I for numerical data.
Figure 1.	The effect of day length and temperature on frond number.
Figure 2.	The effect of day length and temperature on dry weight of fronds.
Figure 3.	The percentage of mature fronds bearing sori at various temperatures and day lengths.
Figure 4.	The percentage of immature fronds bearing sori developing at different temperatures and day lengths.
Figure 5.	The influence of temperature and day length on relative size of the sorus.
Figure 6.	The influence of temperature and day length on the relative number of sori per frond.

influenced by day length. The percentage of fronds bearing sori is correlated with day length. A sixteen hour day is more favorable than an eight or twelve hour day for production of sori. Size and number of sori per frond is not appreciably influenced by either temperature or day length.

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On the Occurrence of Redbud in Indiana[1]

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Distributional records for *Cercis canadensis* L. show that this tree occurs in nearly every county in Indiana. Aerial reconnaissance surveys during the flowering seasons of 1953 and 1954, and more than 5,000 miles of ground travel confirm the state-wide occurrence of the species and its associated form *C. canadensis* L. f. *glabrifolia* Fernald. The latter grows side by side with the typical, pubescent-leaved plant, which suggests that the variation of the leaves is a genetical rather than an ecological difference. A white-flowered form is reported in Henry and Harrison Counties (5) but none was found during our field studies. Redbud is probably as abundant in Indiana now as it ever was.

In Indiana, the abundance of redbud roughly increases from west to east and from north to south. It is most abundant in the southeastern part of the state. Coincident with this distribution is the increase in the abundance of calcareous soil-forming materials from west to east, and the increasing suitability of climate from north to south. Furthermore, the amount of woody vegetation increases southward coinciding with changing land-use patterns from cultivated soils to forested soils and soils being returned to woodland where the successional transgressiveness of redbud is enhanced. Other environmental factors are not necessarily less influential upon the distribution of redbud, but those factors mentioned appear to play the most important parts in governing its abundance.

Light Requirements

Light intensity is very important in determining site suitability, since mature redbud is very intolerant. Its requirement for strong light is not in itself an important factor in governing the general distribution because forested areas usually possess adequate seed sources on sites with suitable light intensities. Elsewhere there is sufficient edge with seed supplies and with adequate light to support vigorous growth, but the lack of redbud seems to be the result of arrested succession.

There is some evidence that the species becomes more shade tolerant in the southern states, but only one place has been found in this state where a large number of trees occupied a prominent position in the understory. This area is found in southeastern Gibson County, on the Bertram Farm, in a cut-over oak-hickory woods which has been a hog lot for many years. Elsewhere redbud grows in the understory more abundantly as saplings than as trees.

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[1] This paper is a condensation of the Indiana portion of the section on occurrence in a Purdue University doctorate thesis (7) dealing with the entire range of the ecological life history of *Cercis canadensis*. That work was supported by a fellowship grant by the Purdue Research Foundation to the authors. Advice on soils from Profs. T. M. Bushnell and H. P. Ulrich is gratefully acknowledged.

Its heliophytic nature is vividly exemplified along the precipitous slopes around Leavenworth where it has almost equal chances of growing either in shade or in full sunlight. Another indication of intolerance to shade is the thin crown canopy of leaves resulting from lack of foliation on the inner branches. An extremely lopsided form is characteristic of redbud when growing in woods edges; frequently the exposed side of the crown touches the ground.

Experiments performed with young redbud growing in the Purdue controlled-climate laboratory showed terminal growth generally ceases when the intensity of incident light falls below 100 footcandles. Lesser intensities may or may not support growth depending upon the vigor of the plant, the air temperature, and the available soil water. Illumination higher than 500 f.c. is supraoptimum. More than 13 hours of light is necessary to maintain terminal growth.

Although the species ecises better in shaded areas, the requirement for high light intensity becomes greater with age. Well established root systems produce year-old sprouts 10 feet tall in full sunlight.

Association with Limy Materials

Redbud attains its most important ecological role in southeastern Indiana where calcareous bedrock outcrops are important soil forming materials. The association with limestone has been shown by Braun (3) in the Cincinnati area, by Read (9) in the Ozarks, by Hopkins (6) and by Anderson (1) in the Arbuckle Mountains, and by information received from botanists in the Great Valley of Virginia. Redbud also occurs with limestone in the area south of Bloomington and Paoli, Indiana; the soils there differ markedly from those of southeastern Indiana in the scarcity of calcareous and carbonaceous clays and shales.

Redbud seldom grows on acid shales. However, it is characteristically present on acid sandstone soils. There are three major sandstone soil regions in southern Indiana differing in their geological make-up. Woods states [Belcher, Gregg, and Woods (2)] that shale constitutes about 50 per cent of the exposed bedrock in Indiana. Some of this shale outcrops in the sandstone area on hillsides along with thin laminations of limestone and clay. Wherever limestone or calcareous shale occurs in the sandstone regions, it might be expected, in view of the effect of limy materials in southeastern Indiana, that redbud would be more conspicuous than on adjacent sandstone.

On soils derived from sandstone, stands are fewer and these are generally less dense than the stands on calcareous sites. As might be expected, the sandstone soils adjacent to the limestone areas bear more redbud than those farther removed. This is chiefly the result of the abundant seed source in the high lime areas.

In the recently glaciated portions of Indiana, redbud grows abundantly on river terraces which are predominantly gravelly and usually of calcareous materials. It does not grow on the sand dunes around Lake Michigan. Redbud was not found on acid wind-blown sands along the principal rivers in southern Indiana (Oaktown soil series), but it grows very well on calcareous wind-blown sands in Knox County (Princeton series). Bushnell's classification (4) is used herein for soil types.

Observations indicate that a certain environmental complex best supports redbud in Indiana. Dark alkaline soils derived from limy parent materials occur on very steep slopes and have adequate moisture for seedling establishment. Sufficient light intensity for mature redbud is provided. However, the plant community as a whole is growing under relatively unfavorable edaphic conditions for the mature trees. One or both of two possible relations might apply between redbud and the edaphic complex on these situations: (1) it is tolerant to soil conditions so that it suffers no appreciable disadvantage, and (2) it is favored by this complex either directly or indirectly by competitive relations with its associates.

The woody vegetation on these alkaline soils is highly diversified. It includes a wide variety of such species as the oaks, hickories, ashes, cedars, walnuts, haws, beech, maple, and tulip-tree. Wilde (10, p. 26) points out that "all trees" on this kind of soil (rendzina) suffer from "malnutrition" because of the high carbonate content of the soil. He indicates that trees there have very low rates of growth, are frequently deformed and are subject to premature death. Furthermore, seedlings seem to be either handicapped by the absence of mycorrhizal organisms or their growth may be inhibited by attacks of damping-off fungi. His observations are probably based upon some well-known effects of soil alkalinity whereby nutrients, especially iron, manganese, boron, phosphate, etc., occur in such insoluble forms that the roots cannot bring enough of them into solution for the requirements of the tree.

Since redbud is most abundant on these highly alkaline soils, and no less vigorous, mineral deficiency does not appear to be a problem there for this tree. It is certainly tolerant to the existing edaphic conditions. In view of Wilde's observations it is suggested that redbud is more tolerant to nutritional shortages than other tree species associated with it, and it

TABLE 1

Chemical analysis of four soil series in Indiana where redbud is exceptionally abundant. These soils represent two extremes in relation to the amount of certain minerals present.

Series, Horizon, and sample number	pH	m.e. per 100 g. Mg	K	P (ppm)	Ex. Ca.	Cation Ex. Cap.
Zanesville 119A	5.6	1.4	.17	5	4.3	12.5
B_1	4.8	3.3	.13	3	2.3	17.3
B_2	5.0	2.4	.11	3.5	6.0	17.0
Zanesville 131A	5.7	1.3	.16	6	5.3	12.5
B_1	4.9	2.5	.09	4	3.0	12.5
B_2	4.7	3.0	.11	5	2.3	14.2
Fairmount 115A	7.7	1.3	.29	76	28.0	28.4
C	7.7	1.1	.18	92	26.2	27.8
Corydon 110A	7.8	1.3	.36	2.5	39.6	36.8

is favored in competition by the high light intensities under their relatively thin canopy. Also, land use patterns involving partial cutting, grazing, and the return of many fields to woodland contribute to the importance of redbud.

Comparison of Some Edaphic Extremes Suitable to Redbud

Nutrient availability on four soil series. In contrast to redbud on the high-lime soils is its occurrence on the very low-lime sandstone sites, namely, the Zanesville soil series, in Martin and Gibson Counties. Most of the roots were found in the A horizon of the soil profile, some in the B_1 horizon, and fewer in the B_2 horizon which extended along with the tap root more than 40 inches into the sub-soil. Table I compares the chemical analyses of these soils with two high lime soil series (Fairmount in southeastern Indiana, Corydon in the area around Leavenworth, Indiana).

The horizons taken from the Fairmount and the Corydon series were only those from which soil was available; beneath these were bedrock. The Corydon series yielded a figure for exchangeable calcium higher than the cation exchange capacity. This is caused by the presence of limestone fragments in the sample used in the analysis. The acid leaching agent reacted with these particles. The analysis reported represents duplicated trials done for us by the Soil Testing Division of the North Carolina Department of Agriculture.

Table I shows that redbud grows in soils where the available calcium is as little as 1,320 pounds per acre of the A horizon (Zanesville from Martin County #119) and as much as 15,800 lbs./A. (Corydon). On the other hand this amounts to 29 per cent of the cation exchange capacity in the Zanesville 119 and should be slightly less than 100 per cent for the Corydon. Judging also from the pH values it is apparent that the Zanesville is very low and the Corydon is very high in calcium content as well as in its availability. There seems little doubt that low quantities of this mineral are not significantly influential in limiting the growth and occurrence of redbud.

The lowest base exchange capacity on which redbud was found was 2.2 milliequivalents per 100 grams of soil in the C horizon of the gravelly Rodman series along Pigeon River in northern Indiana. This is also illustrative of poor site qualities supporting this species. Its tolerance to certain other nutrient factors can be judged from the data presented in Table 1.

Soil water relationships and the occurrence of redbud. The presence of redbud on the gravelly Rodman series as well as in the clayey sub-soils of the Fairmount series sharply illustrates the tolerance to a wide range of textural classes and the water holding capacity of the soil. The tap root descends to indeterminate depths in the gravels and between the layers of bedrock. It probably plays the vital role in survival during the droughty seasons.

Redbud roots will withstand only temporary inundation. These trees have been found on 40 different soil series in Indiana and all the soil profiles showed good internal drainage. Occasionally redbud grows in wayside ditches and in stream embankments, but examination of the root system usually shows that the roots grow away from the saturated soils. Zanesville soil in Martin County has an expansive clayey B_2 horizon which is nearly impervious in the spring. This creates a perched water table which temporarily saturates the upper levels. Tap roots on young redbud in the spring curve upward until the soil water moves away from this impervious layer. Later the soil aggregates shrink, the soil becomes well areated and the tap root descends. A J-shaped root results at the level of soil saturation.

It is not unusual to find redbud growing on limestone ledges with the tap root extending into a soil-barren crevice. On these exceedingly dry sites late in the growing season, probably some moisture from dew on the rocks becomes available to the root hairs. Probably the presence of thick-walled root hairs confers an advantage in such xeric habitats.

The Topographic Ecology of Redbud

Throughout Indiana the land-use pattern largely restricts redbud to the most rugged terrain in any locality. These areas include hillsides, river terraces and slopes, drainage ways, and highway and railroad embankments. This, in part, accounts for its abundance in the unglaciated portion of south central Indiana. On the other hand, the suitability of the habitats on the till plains, drained swamp land, valley fills, and other flat land is readily seen in fields abandoned for 3 or more years.

In southeastern Indiana, because of the steep gradient of the slopes and the short distance from the upland to the Ohio River, the relation of redbud to its associates, to the soils, and to the topography is fully expressed along most transects perpendicular to the river.

Uplands. Redbud is not found on the upland undrained flats, e.g., on the Blanchester soil series, among the mixed hydrophytic trees. Surrounding this woodland is usually cultivated ground on any or on a combination of Clermont, Avonburg, Rossmoyne, Cincinnati, Wynn, Edenton, and sometimes Hennepin soil series from Illinoian till. As the land becomes rolling, especially along drainage ways, Avonburg, Rossmoyne, and Cincinnati series predominate and redbud may or may not be present depending upon the employment of woody vegetation in conservation practices. As slopes become prominent, Wynn, Edenton, and Hennepin usually support woodlands in which redbud is nearly always a component. Both in the understory and along edges this tree is associated with other xeromesophytic saplings as sassafras, buckeye, black locust, hackberry, black walnut, several haws and oaks.

High slopes and bluffs. After the till has eroded away, the soils of the dissected upland, e.g., Switzerland, are residual from the limy bedrock materials. With increasing steepness of slope (20-55%) the Fairmount series is found. Both soil series are occasionally cultivated, frequently grazed, and generally wooded. Grazing on these hillsides has long permitted the establishment of *Crataegus mollis*, other haws, and both locust trees. Their thorny branches and their ability to withstand strong sunlight and droughty conditions, coupled with transportation of the seed through animal feces, are chiefly responsible for their establishment and abundance.

The upper slopes expose Silurian limestones and shales (occasionally the Richmond formation of the upper Ordovician), and it is upon these limy materials in open areas that redbud abounds. These rocks also form the bluffs along the Ohio River in the vicinity of Madison. Red cedar and redbud commonly occupy these bluffs, cedar being the most xerophytic and occupying the more open places. These enter into new sites early and together with the xeromesophytes mentioned above compose the major successional transgressives on the high slopes where sites are being returned to woodland.

Lower slopes, deep ravines, and narrow valleys. The argillaceous Eden shales generally form the lower sides of ravines and valleys near the Ohio River. Farther north the upper Ordovician and lower Silurian formations are found. Fairmount soils still prevail on the hillsides. The vegetation going upslope from the most mesic places consists of willows, sycamore, cottonwood, buckeye, pawpaw, redbud, the elms, hackberry, dogwood, tulip-tree, blue ash, *Ostrya*, sugar maple, the locusts, haws, and oaks. Redbud is common generally, but is most abundant where it receives intense light. Since the flood plains and the high river terraces are generally cultivated where possible, redbud is of necessity confined to woods, fence rows, and the edges of roads and streams. Even in lowland habitats, redbud occupies soils with well drained profiles, usually the Huntington series.

Redbud in relation to exposure of slopes. Potzger and Friesner (8) assembled extensive data in their evaluation of the climax species in southern Indiana. They counted 28,842 woody stems of 73 species on 48 slopes, exposures, and ridges in Franklin, Bartholomew, Monroe, Brown, and Morgan counties. Calculations based upon their data show redbud, on the basis of total stems on all exposures, had a relative density of 0.71 per cent when compared with all tree species. If only the situations on north and south slopes are compared redbud is more abundant on southern exposures; the relative density is 1.42 per cent, that on the north slopes is 0.32 per cent.

In order to get the over-all relation between this species and its associates both the relative density and the relative frequency for each of the 73 species were calculated from the data presented by those authors. The sum of these values for each species provides an index (RD-RF index) having a maximum value of 200 per cent. I.e., a pure stand of only one species constituting the entire aggregate sample would have a RD-RF index of 200. The index expresses both number of stems and their uniformity of dispersal. One index was calculated for the occurrence of each species on the north slope and another index for the south slope. The species were listed for each slope-type in the order of decreasing values of the indices.

Redbud on north slopes occupied 32nd position with an index of 0.89, while on south slopes it stood 21st with an index of 2.24. This clearly shows redbud is here a species characteristic of southern exposures, and apparently has fewer serious competitors there. Sugar maple occupied first position on both exposures with 43.70 on the north and 19.99 on the south. This treatment of Potzger's and Friesner's data also supports their conclusions about the climax species in southern Indiana.

Redbud on the south slopes is, roughly, three times as prominent (in terms of this index) as it is on the north slopes. It was found that redbud on the south slopes (2.24) is almost as prominent as such north slope species as *Benzoin aestivale* (2.28), *Hamamelis virginiana* (2.31), *Quercus velutina* (2.39), and *Liriodendron tulipifera* (2.66). Conversely, redbud on the north slopes (0.89) compares with those species on the south slopes as follows: *Liriodendron* (0.58), *Carpinus* (0.63), *Benzoin* (0.69), *Dirca palustris* (0.92), and *Carya cordiformis* (0.94). An interesting result of this arrangement is that redbud on the south slope has about the same index as tulip-tree has on the north. Since their data incorporated size classes down to 1 meter height, and redbud is most numerous as immature individuals of which few will survive, the importance of mature redbud is not nearly so great.

Flowering

Redbud generally flowers sometime between April 1 and May 15 throughout the state. However, a statistical evaluation of known blooming dates in comparison with actual temperatures suggests flowering is normally expected (with 95 per cent confidence) when the average daily mean temperature reaches 52-58 degrees F. Statistical analysis of 18 years of blooming dates recorded by Dr. C. C. Deam in his arboretum at Bluffton, in comparison with temperature means calculated from meteorological records of the adjacent Bluffton Water Works for the same years, shows that redbud comes into flower following a 30 day period for which the daily mean temperature averages 47-53 degrees (95 per cent confidence). Abnormally high temperatures (i.e. higher than the normal temperatures for the calendar period) usually precede flowering for about two weeks.

Outstanding Individual Specimens

The largest redbud found in Indiana is the Fairfield Redbud, along state road 101 near the Union-Franklin county line. It measured 25.3 inches in diameter at 30 inches from the ground in 1953. In its senescent status it is broken, weather-beaten, and laden with poison ivy, wild grapes, and Virginia creeper. In the spring of 1954 it was nearly dead. One tree with exceptionally well balanced form and vigor occurs at 1505 N. Main Street, Petersburg. The trunk measured 17 inches in diameter below the lowest branch at 28 inches above ground. A large tree in Allen County is shown in Figure 1; this photo was taken in 1937 by Mr. Frank Wallace, and is used here through the courtesy of Prof. Daniel DenUyl. The tree was still alive in 1947. Calculations based on the diameter of the hat crown in the picture show this redbud was approximately 30 in. d.b.h. The largest known redbud occurs near North Kingsfield, Ohio, with a diameter of more than 30 inches and a crown spread of more than 40 feet.

Crown Cover

Redbud when in flower is conspicuous from the air and well suited for determination of its crown cover by vertical 35 mm. kodachrome transparencies taken from airplanes at 1500 ft. above ground by a hand-held

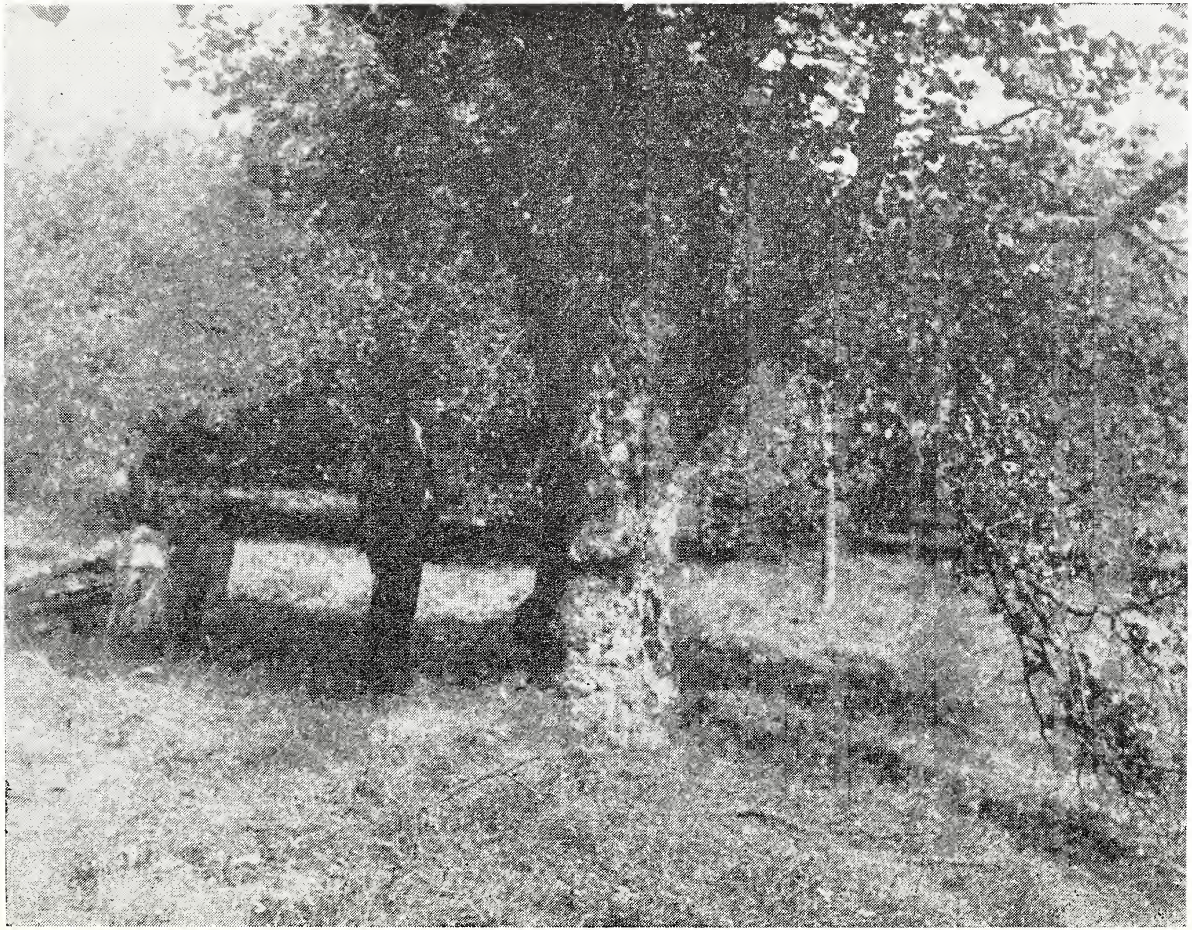

Fig. 1. Large redbud near Huntertown, Allen County, photographed in 1937.

camera. Such photographs were projected in a darkened room upon smooth white tag paper previously ruled into one-inch squares. The image was about 48 x 36 inches. The pink redbud crowns were measured where they intercepted the vertical and horizontal lines; the total line cover for redbud divided by the total length of the lines yields the proportion of coverage. Expressed as per cent, this represents ground coverage. Seven representative sites where redbud is prominent in southeastern Indiana were thus studied. The maximum redbud coverage found for tracts as large as 10 acres was 22 ± 1 per cent of the area. In areas of 1 acre, selected for maximum coverage, the redbud crowns occupy as much as 90 per cent of the ground.

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Some Observations on the Tree Strata of an Oak-Hickory Woods[1]

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In 1951, Northern Illinois State Teachers College acquired a sixty-six acre tract of land to be preserved as an outdoor laboratory for the natural sciences and for teacher training. This study was made to determine the composition of the tree strata of the higher topographic positions of the area, some of the reasons for the variations present, and to gain some knowledge of the climax relationships of this part of the midwest.

The area studied is located in the N. W. ¼ of Sec. 33, T. 24 N., R. 10 E. of the Fourth Principal Meridian, in Ogle County, Illinois. It lies within the Till Plains section of the Central Lowlands Province, called the Rock River Hill Country by Leighton (5). Relief may be as great as 155 feet in a half mile. The hill tops are covered with a thin mantle of Illinoian glacial till. Platteville limestone of Ordovician age makes up the bedrock of the region (1, 3, 5). The climate is continental; temperature ranges from 100°F. to —10°F. The mean annual precipitation is thirty-four inches (1, 3).

Methods

Twenty-two 10 x 10 meter quadrats were subjectively placed to fall at the higher topographic positions. Within these higher positions they were placed at fifty or one hundred pace intervals depending upon the size of the ridge. About ten acres are included in the higher topographic positions thus resulting in approximately a five per cent survey. The largest ridge top in the area was omitted because of introduced vegetation around various buildings.

Discussion of Results

A compilation of the data collected by means of the quadrat method appears in Table I. It can be seen that one species had the highest index in all three phases of critical tree measurement. This species, *Quercus alba*, covered 0.222441 per cent of the total area sampled, occurred in 95.4 per cent of the quadrats, and averaged 3.409 individuals per quadrat. The numbers quoted refer to basal area, frequency, and density in that order. From Table I, it is seen that *Quercus rubra* and *Carya ovata* ranked high in basal area, frequency, and density. This is an indication of co-dominance.

Quercus velutina had a comparatively high index of basal area and a low index of frequency and of density. This indicates that although there were only a few members of the species present, they were large. *Quercus rubra* had a high frequency and density, but a low basal area. This indicates a large number of small trees that can compete with the shrub strata, but rarely grow to maturity.

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[1] This paper is based on a Master's qualifying paper deposited in the library, Northern Illinois State Teachers College. The author wishes to thank Dr. Robert A. Bullington who directed the research.

Prunus serotina had high frequency and density indices and medium basal area. These facts are not significant in themselves, but when combined with observation of the association, it is seen that *Prunus serotina* grows to maturity, but not usually in large numbers.

The above facts combined with the field observations of the investigator lead him to conclude that the hill-top stratum in this area is dominantly oak-hickory *(Quercus alba, Quercus rubra—Carya ovata)* interspersed with black cherry. In the following discussion, the hill-top tree stratum will be related to topographic position. This analysis supplies further information relative to the climax relationship of this area.

Table II indicates that the largest number of species reaching optimum development occurred at the lowest topographic position, on the slope of the hill, a well-drained spot. This could be interpreted as indicative of the most mesarch environment. This is further substantiated by the fact that *Quercus rubra*, a tree that grows well in moist soil, reached its optimum development at the same topographic position. Even though *Quercus rubra* reached an optimum development at this elevation, it was not dominant, but co-dominant with *Quercus alba*. It can be said that dominant trees share the ground with other trees, but in such a situation they are not as frequent as they may be in another environment where they are the dominant species.

One species, *Quercus alba*, showed a decrease in density and an increase in basal area with an increase in elevation. *Quercus alba* reached its maximum size at the highest topographic position. *Quercus velutina*, at its maximum development in this area, occurred only as a minor-dominant on the more xerarch hilltops.

From the facts presented above, and the observations made in the field, it is the opinion of this author that *Quercus alba* is the dominant tree of the higher topographic positions in the area studied. Other species share this dominance as co-dominants or minor-dominants under certain conditions. At the lowest topographic positions, *Quercus alba* is dominant, with *Quercus rubra* co-dominant. *Quercus velutina, Carya ovata,* and *Prunus serotina* are three minor-dominants. *Quercus alba, Carya ovata,* and *Quercus rubra* are co-dominant at the medium topographic positions. At the highest topographic positions, *Quercus alba* is dominant, with *Prunus serotina* and *Carya ovata* as co-dominants. At this position, *Quercus velutina* and *Carya cordiformis* are minor-dominants.

Quercus alba, Carya ovata, and *Quercus velutina* are dominant trees because of their ability to succeed on well-drained land. The limestone bedrock with its thin mantle of glacial till offers the dry environment which these trees favor. *Quercus velutina* probably preceded *Quercus alba* on these dry (xerarch) exposed hills and are then responsible for the more mesarch conditions which now exist. The increase in density and basal area for *Carya cordiformis* is probably due to the presence of prairie openings at the highest topographic positions.

The lower elevations, being subject to less erosion, and sometimes collecting part of the material eroded from the higher land, especially colloidal material, would therefore have a thicker mantle of soil material. This thick material would be capable of holding more moisture and would

TABLE I

Species	Basal Area[1]	Frequency[2]	Density[3]
Quercus rubra	0.0486916	59.50	1.769
Quercus velutina	0.0124496	22.72	0.409
Quercus alba	0.2224410	95.40	3.409
Carya ovata	0.0361177	72.70	1.636
Carya cordiformis	0.0009675	45.40	1.500
Quercus macrocarpa	0.0014203	4.54	0.272
Fraxinus americana	0.0005514	2.72	0.590
Tilia americana	0.0068475	31.81	0.545
Ostrya virginiana	0.0023425	31.81	0.590
Acer negundo	0.0005247	18.10	0.409
Juglans nigra	0.0074760	31.80	0.409
Celtis occidentalis	0.0006955	27.21	0.500
Ulmus fulva	0.0029030	50.00	0.725
Prunus serotina	0.0060424	59.00	2.000
Acer saccharum	0.0000230	4.54	0.045

Basal area: Expressed in percent of square meters ($\pi r^2/2200$)

Frequency: Per cent of quadrats in which species occurs (N/22 x 100)

Density: Average number per quadrat (X/22)

TABLE II

	Position I[1]		Position II[2]		Position III[3]	
Species	Den.	B. A.	Den.	B. A.	Den.	B. A.
Quercus velutina	0.1	0.061275	0.9	0.007251	0.25	0.005685
Quercus rubra	2.3	0.108865	2.2	0.060096	0.75	0.095566
Quercus alba	3.5	0.020713	2.2	0.224793	3.50	0.404699
Quercus macrocarpa			0.9	0.004469		
Carya ovata	1.6	0.060394	1.7	0.045178	1.50	0.018775
Carya cordiformis	0.7	0.000525	1.1	0.000783	2.60	0.002882
Prunus serotina	4.1	0.148563	1.2	0.005657	1.00	0.030243
Ostrya virginiana	0.3	0.001247	0.9	0.003972	0.10	0.001666
Ulmus fulva	0.5	0.005558	0.7	0.004238	0.70	0.001733
Fraxinus sp.			1.7	0.001032	0.10	0.000464
Celtis occidentalis	0.7	0.002172	0.1	0.000157	0.10	0.000013
Tilia americana	1.0	0.015909	0.2	0.000608	0.40	0.011456
Juglans nigra	0.2	0.000129	0.9	0.024269	0.30	0.000517
Acer negundo	0.5	0.000290			0.60	0.002369

Density and basal area compared with topographic position.

Position I: Characterized by accumulation of erosional and colloidal materials.

Position II: Slope of the hill immediately below crest.

Position III: Crest of the hill.

support a different type of vegetation. *Quercus rubra* can survive the moist soil conditions, and in this area reaches its optimum development at the lower elevations.

In Tables I and II there are listed many minor species of trees. Some of these species, such as *Ostrya virginiana* and *Juglans nigra* are characteristically found in oak-hickory communities. They rarely become part of the dominants, but *Juglans nigra* may form small societies in particularly favorable locations. *Ostrya virginiana* is often found in association with the oak-hickory community as part of the tall shrub or sapling strata under the canopy. Accessory trees forming a part of these strata are *Celtis occidentalis* and *Ulmus fulva.* These usually die out before their size warrants them a place in the canopy strata. In a clearing or open area they will pave the way for the oaks, or momentarily occupy the place of some large tree that has succumbed to disease, lightning, or old age.

Summary

The results of the quadrat method showed *Quercus alba* to be the dominant tree species at all physiographic positions studied. At the lower positions, *Quercus alba* was found to share this dominance with *Quercus rubra. Carya ovata* and *Prunus serotina* occur as minor-dominants. At the intermediate positions, *Quercus alba* shares dominance with *Quercus rubra* and *Carya ovata.* At the highest positions, *Quercus alba* is dominant, with *Prunus serotina* and *Carya ovata* occurring as co-dominants. At all elevations sampled, accessory species may occur in the canopy, but do not constitute enough of the community to be considered dominant.

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CHEMISTRY

Chairman: R. G. Larson, Valparaiso University

John A. Buehler, Anderson College, was elected chairman for 1955

ABSTRACTS

The Solubility of Silver Nitrite in Aqueous Solutions of Potassium Nitrate. Martin Allen and William C. Needler, Butler University.—This is a preliminary report on a study of the solubility of silver nitrite in aqueous solutions of potassium nitrate at 25° C. The apparent inapplicability of the Debye and Hückel theory to the experimental results indicates that several ionic equilibria are probably involved. A plausible interpretation of the data can be obtained on the assumption of incomplete ionization of silver nitrite.

Instrumentation—Proposed New Major at Marian College. Sister Mary Rose Stockton, Marian College. — Papers on instrumentation courses in the graduate schools and senior classes appearing recently in the literature seem to deplore the fact that there is not enough time in the present one- and two-semester courses to cover all the material as well as it should be covered. This gave the author the idea that perhaps it is now time to offer a major in instrumentation in the undergraduate school. She wrote to instrument manufacturers, distributors, and friends who might be interested, to ask their advice as to the feasibility of such a plan. The response was so encouraging and gratifying that she has prepared a course of studies leading to a major in instrumentation and has outlined in a preliminary manner the courses in instrumentation that will be offered and some of the material to be covered in each course.

Resonance in B-Bromovinyl Ethyl Ether as Indicated by Infrared Spectra. T. C. Schwan, Valparaiso University, and C. C. Price, University of Pennsylvania.—Infrared data for vinyl bromide, ethyl vinyl ether and B-bromovinyl ethyl ether are discussed. Resonance in these compounds is also discussed. It is shown that in B-bromovinyl ethyl ether, the resonance effects of the bromo and ethoxy groups oppose and nullify each other as indicated by the infrared data.

The Ultraviolet Absorption Spectra of Hexachlorocyclopentadiene and derivatives. E. T. McBee, C. W. Roberts and J. D. Idol, Jr., Purdue University.—The absorption spectra for hexachlorocyclopentadiene and a number of its derivatives have been determined in the 200 to 400μ region. The bathochromic and hypsochromic shifts resulting from extensive chlorine substitution on the cyclopentadiene and cyclopentene nuclei have been evaluated. This information has been used to help confirm or disprove the structure of some derivatives of hexachlorocyclopentadiene.

Fluorine-containing Anesthetics. E. T. McBee, D. H. Campbell and C. W. Roberts, Purdue University.—The results of the testing of organic fluorine compounds for anesthetic activity, flammability in oxygen, and stability to alkali have been examined and several empirical relationships have been obtained which have enabled the determination of the structural features desired in compounds to be tested as inhalation anesthetics. Fourteen organic fluorine compounds were tested for flammability in oxygen and for stability to alkali and the results concur with the relationships obtained.

The flammabilities in oxygen of the compounds were determined by sparking a series of mixtures of the compound and pure oxygen in an apparatus that permitted closed observation of the point of ignition. The stability to alkali was determined by treatment of the compounds with strong sodium hydroxide solution for one day at fifty degrees.

A Study of Physical Properties Relationship for Binary Mixtures of Methyl and Ethyl Alcohols

R. G. Larson, Valparaiso University

The objective of this study was to obtain graphical representations of physical properties vs. composition for the binary system of methyl and ethyl alcohols and to do this in such a manner as to reveal similarities of linear relationships or deviations from linear relationships for the physical properties of the binary solutions. Data for a temperature of 25 degrees centigrade were accumulated from literature for the properties: density, refractive index, surface tension, vapor pressure, heat capacity, and viscosity.

It is well known by many that vapor pressure and boiling point graphs for binary solutions show relationships which are described as linear or deviations from linearity. These deviations may be to such extent that maxima or minima may be present. It is also known that similar relationships occur for other properties of solutions. The author became curious as to the nature of the relationships for the other properties of the same solutions. If linear relationships existed for one property, was such a relationship to be expected for some other properties? In order to make a comparison of properties it was considered essential to obtain properties data for the same solutions at the same temperature. The properties of the same molecular aggregate would hence be compared.

Method of Graphical Representation

The method for graphing data is similar to that for vapor pressure or boiling point vs. composition relationships for binary systems. The composition is represented on the abscissa axis with the pure components represented at the two ends and the compositions of the mixtures proportionately in between. The ordinate axis is used for the physical property variable and is spotted at two fixed points. These points are the same on all graphs for the system and represent the physical property value for each of the pure components. A linear relationship will be represented by a straight line between these points.

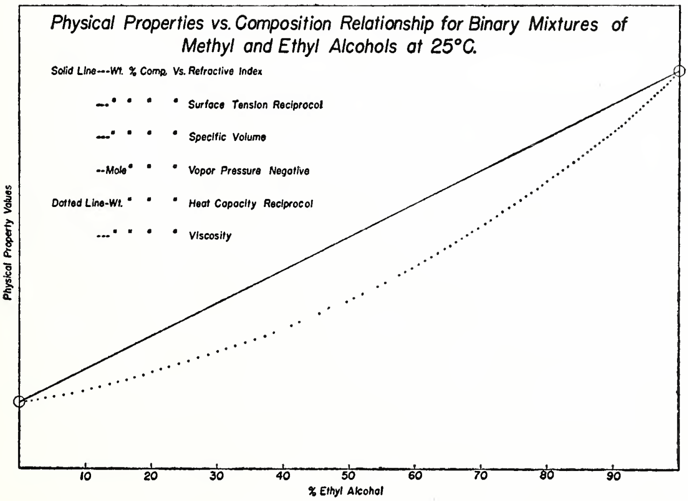
In order to obtain graphs which had the same general slope, it was found necessary to sometimes plot a function of the physical property in place of the property itself. This made it possible to have values increase in magnitude reading upward on the graph. Reciprocal and negative functions were used in this study.

Literature data gave composition values in different units. It was hence decided to leave the composition axis general in nature and indicate the composition unit by means of a solid line, dotted line, etc. Weight per cent and mole per cent units were used in this work.

Results

Data were taken from references as indicated in "Literature Cited" given at the end of this report. Refractive index values were taken from an unpublished master's thesis by Larson. The weight per cent composition vs. refractive index relationship was linear. Surface tension data at 25°C. were interpolated from data by Morgan and Scarlett. Values for 0°C., 30°C., and 50°C. were given. The change of surface tension with temperature was found to be linear and hence extrapolation for temperature of 25°C. was valid. A plot of weight per cent composition vs. surface tension reciprocal gave a linear relationship of same slope as for refractive index relationship. Density data were obtained from reference of Herz, and Herz and Kuhn. A plotting of weight per cent composition vs. density reciprocal (specific volume) gave a linear relationship. Vapor pressure data were obtained from reference by Schmidt. Values for 25°C. were calculated from data given at other temperatures. A plot of mole per cent composition vs. vapor pressure negative gave a linear relationship. Viscosity data were obtained from references by Herz and by Bingham, White, Thomas and Cadwell. Heat capacity data were obtained from reference by Bose. It was found that a plot of weight per cent composition vs. viscosity in one case and heat capacity reciprocal in the other case, gave identical curves which were not linear but had a negative deviation from linearity.

Graph I



These results may be condensed into one graph. This is shown in Graph 1 where the solid line represents the linear relationship for 1) wt. per cent comp. vs. refractive index, 2) wt. per cent comp. vs. surface tension reciprocal, 3) wt. per cent comp. vs. specific volume, and 4) mole per cent comp. vs. vapor pressure negative. The dotted line represents the relationship for 5) wt. per cent comp. vs. heat capacity reciprocal and 6) wt. per cent comp. vs. viscosity.

Conclusion

The binary system of methyl and ethyl alcohols shows linear relationships for the properties refractive index, surface tension, density or specific volume when related to weight per cent composition and also for vapor pressure when related to mole per cent composition. Heat capacity and viscosity show a small departure from linearity when related to weight per cent composition. The graphical method presented serves well for the study of deviations of the properties of solutions from linearity and also enables a condensation of data into one graph.

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A High-Pressure Calorimeter for Specific Heats of Aqueous Solutions Up to the Critical Temperature[1]

FRANK T. GUCKER, JR. and JOHN M. CHRISTENS,[2,3] Indiana University[4]

Studies of the heat capacities of aqueous solutions of electrolytes near room temperature, made to test theories of the nature of these solutions, have been summarized recently by one of us (2). Since the complications of hydrogen bonding in water decrease at high temperatures, we determined to study the heat capacities of solutions of typical electrolytes up to the critical point of water, 219 atm., 374.18°C., using the adiabatic twin-calorimeter method previously developed by the senior author and his collaborators (3). Two nearly identical calorimeters, containing respectively known quantities of solution and of water, are surrounded by an adiabatic jacket to minimize heat losses, and heated electrically. The heaters are connected in series and their resistances can be varied in steps so that the resistance ratio, and hence the ratio of the energy inputs, can be adjusted to equal the ratio of the total heat capacities of the two calorimeters. The heaters form two arms of a Wheatstone bridge by which the resistance ratio can be measured accurately. After correcting for the small thermal unbalance, the resistances of the heater leads, and the heat capacity of the calorimeters, the specific heat of the solution can be determined relative to that of water at the same temperature.

Since the heat capacity of water has been determined up to the critical temperature by Osborne, Stimson, and Ginnings (4, 5), it serves as a convenient reference substance in our system. In order to work with single-phase liquids in the calorimeters, we determined to make the measurements at a constant pressure, greater than the equilibrium vapor pressure of water at each temperature. Our measurements require bomb calorimeters capable of withstanding high pressures, an arrangement for bleeding off excess liquid as the temperature rises, and many other complications not experienced at temperatures below 100°C. This progress report describes the design and some preliminary tests of the new calorimetric equipment.

Bomb Calorimeters

The bomb calorimeters shown in Fig. 1 are cylinders 6 cm. long and 6 cm. inside diameter, with hemispherical ends, and hold 275 cc. They are made from Elastuff 44, a high-temperature steel, with a wall thickness of 6.4 mm., giving adequate strength for vessels of this favorable shape. Each is fitted with a platinum-clad nickel liner *L* to prevent corrosion by electrolytic solutions at high temperature. The calorimeters are made in two halves, threaded right- and left-handed respectively, so that they can

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[1] This work was supported by the U. S. Office of Naval Research under Contract No. N6ori-18007 with Indiana University.

[2] Present address: Technical Section, E. I. du Pont de Nemours, Kinston, N. C.

[3] Taken from a thesis submitted by John M. Christens in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[4] Contribution No. 667 from the Chemical Laboratory of Indiana University.

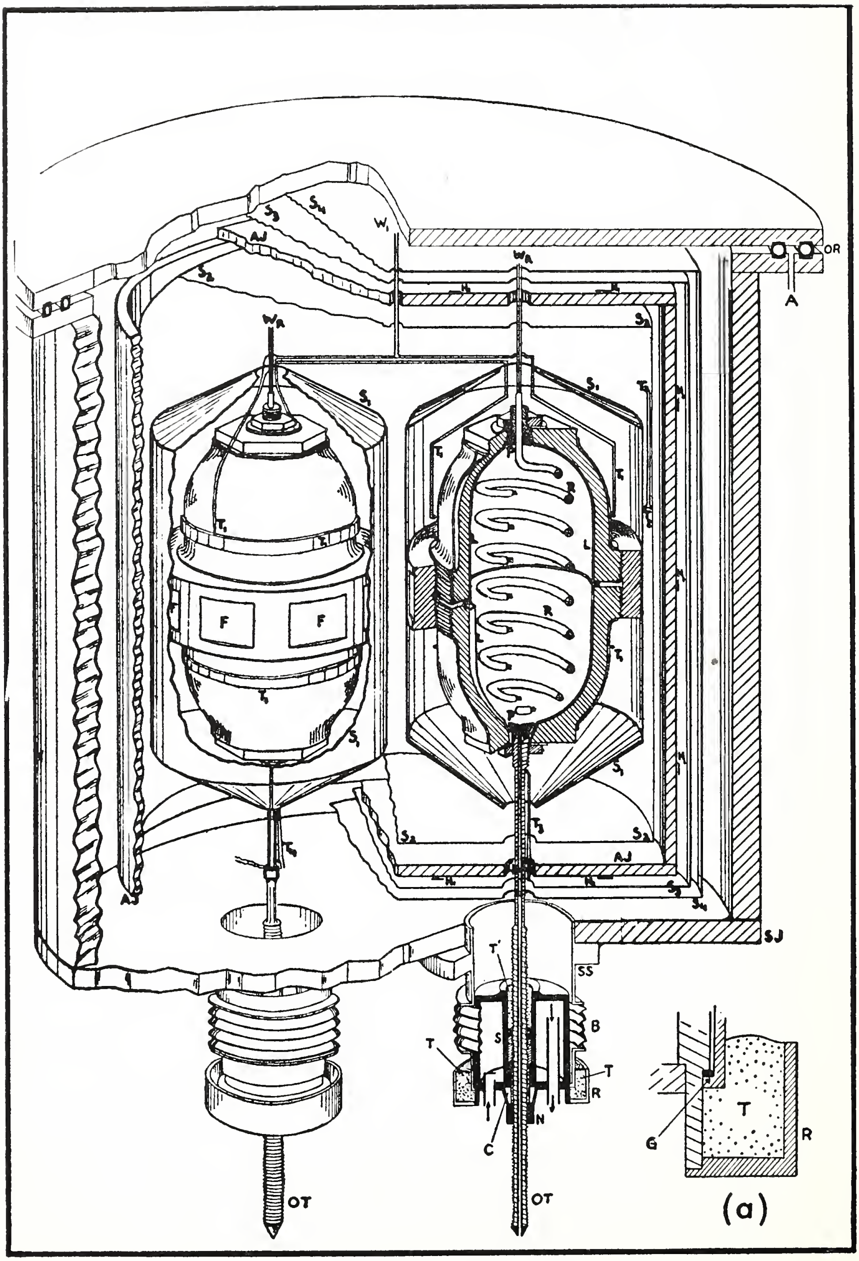

Fig. 1. Calorimeters, radiation shields, and jackets.

be screwed together by a threaded belt. The halves are held by their hexagonal ends in a special vise, while the belt is rotated by an octagonal wrench fitting the surfaces *F* so that the two halves are pressed together on a platinum gasket 1 mm. thick, without relative rotation which could shear the lip of the liners. The spherical section of each liner ends in a tapered nipple of pure platinum into which fits a tapered platinum plug *P*. In each calorimeter the upper plug carries a platinum tube incasing the heater while the lower one is fastened to the platinum-lined outlet pressure tube *OT*. We encountered great difficulty in getting tight seals with these plugs until after very careful grinding with a mixture of fine jeweler's rouge and mineral oil. Liquid in the heated calorimeter touches only the platinum liner or joints "platinum soldered" with a gold-platinum alloy. The outlet tubes pass through water coolers, *CW*, beyond which the liquid is at room temperature and stainless steel tubing is satisfactory.

The adiabatic jacket *AJ* is made of 13-mm. copper supported by Mycalex studs (not shown) resting on the bottom of the 10-mm. steel jacket, *SJ*. The temperature of the adiabatic jacket is controlled by means of evenly-spaced heaters H_1 of nichrome or constantan ribbon or wire insulated with woven glass, mica, Mycalex, or Micamat, all of which unfortunately are fragile and brittle.

A Leeds and Northrup Type 8164-A platinum resistance thermometer (not shown) in contact with the adiabatic jacket, is used to determine the experimental temperature. Differences in temperature between the various parts of the apparatus are measured with chromel-constantan thermels, for maximum sensitivity. A 20-junction thermel T_1, with junctions spaced around the two halves of each calorimeter, measures the difference in temperature between the calorimeters, while four-junction thermels T_2 measure the difference between each calorimeter and the adiabatic jacket, and similar four-junction thermels T_3, T_4 measure the difference in temperature along the outlet tubes.

Since radiation losses become more important than conduction at high temperatures, each calorimeter is surrounded by a 0.01 mm. silver radiation shield, S_1, and the adiabatic jacket is lined with aluminum foil S_2 and surrounded by two aluminum radiation shields, S_3, S_4.

Conduction along the solid connections between each calorimeter and its environment is minimized by suspending it from the lid of the adiabatic jacket by means of an Inconel spring and very fine Inconel wires (not shown), using as fine wire as possible for heater leads and thermels, and especially by reducing each outlet tube to 3 mm. o.d. for a considerable distance, and supplying it with a separate heater H_2 to keep its temperature the same as the base of the calorimeter, as measured by the thermels T_3 or T_4. Gaseous heat conduction is minimized by evacuating the entire steel jacket.

Vacuum

Heat losses by gaseous conduction are known to be proportional to pressure between 1 mm. and 5 microns (1). Below 1 micron, they are negligible compared to radiation, hence we aimed to maintain the vacuum in this range. A D.P.I. Type MCF-60 oil diffusion pump, backed by a mechanical forepump, is connected to the bottom of the steel vacuum jacket through a large tube not shown in Fig. 1. The top of the jacket is sealed with two concentric O-rings, *OR*, the annular space between which is evacuated through a connection *A* to the forepump, to reduce leaks at the seal. The outlet tubes *OT* are fastened with seals which can be broken to remove the calorimeters. Each tube passes through a sleeve *SS*, welded to the jacket and silver-soldered to a flexible Sylphon bellows *B* carrying a brass sleeve at the bottom. A small water cooler slips over tube *OT* to bear against the (crosshatched) threaded sleeve *S*. The connection is made tight by varnishing the threads, filling the narrow trough T_1 with Woods metal, and compressing a Teflon cone *C* against the bottom of the cooler with a brass retaining nut N. As shown in detail (*a*), the cooler is sealed to the bellows by a thin rubber gasket *G* compressed between a recess on the outside of the cooler and the lip on the sleeve at the bottom of the bellows. This joint is submerged in a Woods metal trough *T*, formed by the removable rim *R*. During operation, a controlled flow of water is circulated through the coolers; during assembly or disassembly, this is replaced by steam to melt the Woods metal seals.

The electrical leads, W_1, W_R, etc., about 80 in number, pass through a tube in the top of the jacket (not shown in Fig. 1) connected to a brass junction box, 25.4 x 8.9 x 8.9 cm., with a removable lid sealed by a thin rubber gasket and a Woods-metal trough of the type described above. All of the power leads are fastened to silver studs held in a Mycalex plate. These in turn are connected to the insulated Kovar rods of Stupakoff vacuum seals soft-soldered in the side of the box. The leads of the thermels and platinum resistance thermometer go directly through the Kovar tubes of similar seals so as to avoid soldered junctions which may produce parasitic emf's where the temperature gradient is so large.

The vacuum is measured by means of a large McLeod gage covering the range of 30 to 0.001 micron, connected to the junction box as far as possible from the pump, so that it would give an upper limit to the pressure in the system. After coating all of the Woods metal seals, lead-in seals, and high-vacuum tubing with Glyptal, we obtained satisfactory operation. The diffusion pump could be started less than a half hour after the forepump, and the ultimate vacuum obtained within about two hours. After packing the tops of the five vacuum stopcocks with the Apiezon grease, a vacuum of 0.05 micron was obtained, and the apparatus was operated for several weeks at about 0.2 micron.

Auxiliary Equipment

Fig. 2 is a schematic diagram of the whole apparatus. The outlet tubes from the calorimeters pass through the coolers *CW* and are connected to high-pressure crosses, each equipped with a safety blow-out disc *BO*. A side connection from each tube leads to a combined inlet and bleeder valve through which the calorimeter is filled with water or solution from the appropriate glass flask *SF*, or evacuated through the vacuum pump *VP*. The connections at the bottom of the crosses lead to glass capillary tubes which serve as level gages *LG* where the meniscus between the water (or solution) and a mercury column is visible. The

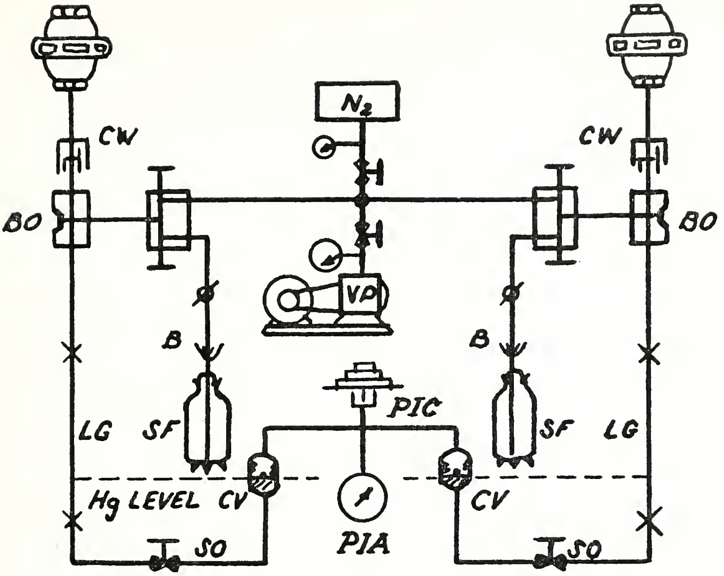

Fig. 2. Auxiliary equipment for calorimeters.

mercury columns extend through U-tubes to an oil pressure line. In each case the mercury-oil meniscus serves to control the operation of a ball check valve *CV* which prevents the loss of liquid from both calorimetric systems in case of the failure of one. The oil pressure lines join in a cross to which is connected a Bourdon pressure indicator and alarm *PIA* and a dead-weight pressure indicator and control *PIC*.

The two flasks *SF* are attached to the bleeder valves through seals made tight with compressed O-rings, while ball-and-socket joints *B,B* in their stems can be loosened to permit weighing for a gravimetric material balance. Pressure in the calorimeters can be generated either by thermal expansion due to heating or by a hydraulic cylinder (not shown) attached to the dead-weight gage.

Safety Devices

In order to operate the apparatus continuously for periods of several days to a week, fully automatic protection must be provided with at least semi-automatic operation while thermal equilibrium is achieved. The safety system shown in Fig. 3 consists of a series of eight servo-mechanical safety devices A_1-A_8 which operate the 6 v. D.C. safety circuit shown in the third row. When everything functions satisfactorily these devices, either directly or through the relays B_1, B_3, B_4, B_5, B_8, actuate the intermediate relay B_9 and through it the power relay B_{10} which completes the circuits to the D.C. calorimeter heaters H_7 and the Powerstats P_1-P_5 supplying the A.C. heaters H_1-H_5. During successful operation, all of the 6 v. lamps L_1-L_8 are off. In case of failure involving any of the eight safety

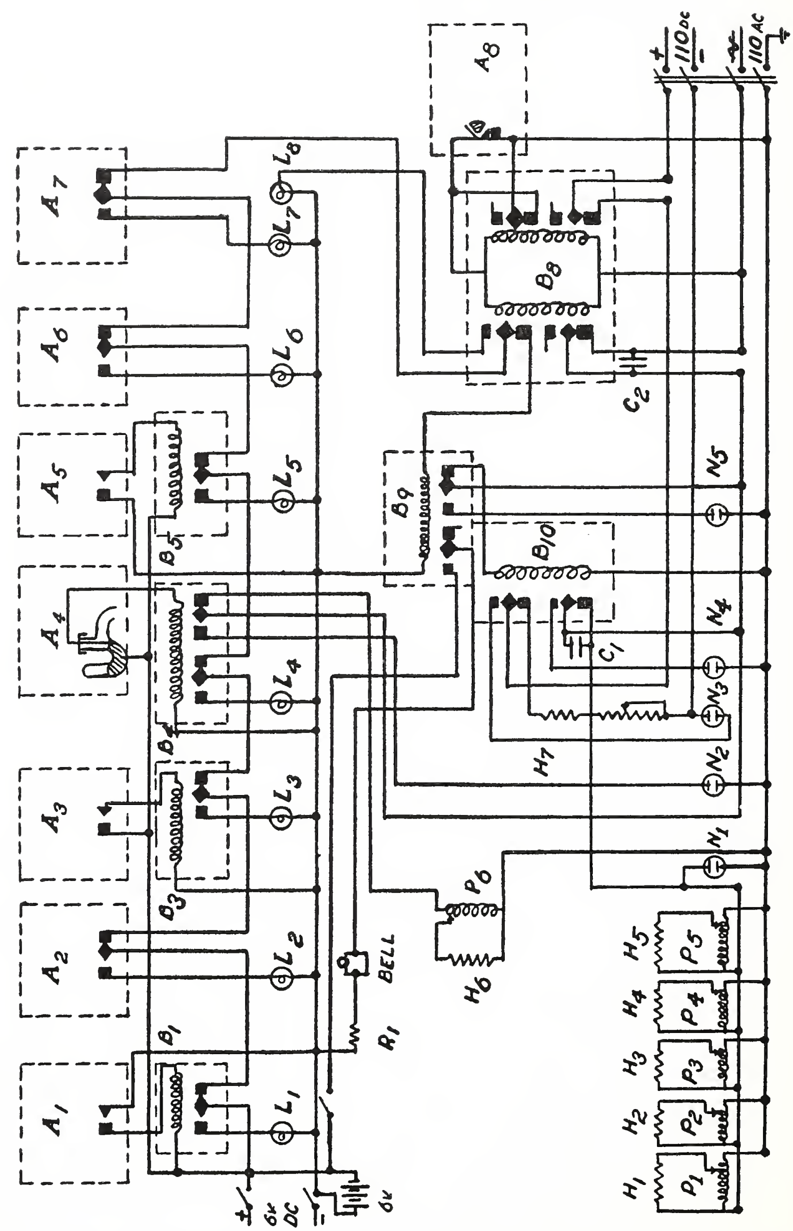

Fig. 3. Safety system. A_1-A_8, safety devices; relays are Potter and Bromfield model KR5D(B_1,B_5), KRP11D(B_4,B_9), and PR11A(B_8,B_{10}) and Clare Series 200(B_3); $C_1 = 0.05$ μfd., $C_2 = 0.01$ μfd. All other symbols are explained in text. All contacts are shown in the position corresponding to satisfactory operation.

devices, the corresponding lamp lights up indicating the defect; relay B_8 is de-energized, causing the alarm bell X to ring and interrupting all power on the heaters of the calorimeters, H_7, the adiabatic jacket, H_1, H_4, H_5 and the outlet tubes H_2, H_3, until the operator corrects the defect. The condition of the power circuits is indicated by a series of neon lamps N_1-N_5, of which only N_1 glows during satisfactory operation.

The different safety devices are: (1) A_1, an adjustable metallic arm attached to a knob in the center of the Bourdon gage which makes contact with the pointer of the gage when the pressure reaches a preset limit, actuating relay B_1. (2) A_2, a microswitch mounted on the deadweight gage with its feeler arm just above the floating piston which rises when the pressure exceeds the weights on the gage, operates the microswitch, and picks up two extra 50-psi weights which prevent further motion. (3) A_3, the metallic contact of a Detect-a-Fire which is set to close at 725°F., actuating relay B_3. (4) A_4, a U-tube containing mercury which rises in the open end to maintain contact with a tungsten wire as long as the pressure in the system remains below about 2 mm. Breaking of this contact deactivates relay B_4 and turns off powerstat P_6. Thus the diffusion pump heater H_6 is interrupted by a vacuum failure. This system is not altogether satisfactory since the jets of the diffusion pump break down at 0.3 mm., and some difficulty was experienced in degassing the mercury in the closed arm of the U-tube, particularly if it is sparked with a Tesla coil. (5) A_5, a mechanical contact closed by the failure of the Mycalex studs supporting the 60-lb. adiabatic jacket. Since Mycalex deteriorates at about 410°C., these studs are backed by slightly shorter broad steel ones which support the jacket if the Mycalex fails. One of these steel studs has a bare wire stretched across its upper surface which closes the electrical circuit and actuates relay B_5 if the adiabatic jacket touches it. (6) A_6, a reset-type microswitch operated by a Lucite piston fitting into a pipe connected to the outside of the blow-out discs. The bursting of either of these at a known pressure of 1500-3500 psi blows the piston against the feeler arm of the microswitch and actuates the safety circuit. (7) A_7, a microswitch controlled by the cooling water, operates the safety circuit if the flow drops too low. The returns of the four coolers for the outlet tubes, junction box, and diffusion pump all pass through a common manifold into a small can with perforated bottom, balanced on a hinged side arm the other end of which is threaded for appropriate adjustable counterweights. A given rate of flow maintains a certain hydrostatic head in the can, which a moderate decrease in the flow of any one of the coolers reduces enough to actuate the microswitch. (8) A_8, a push-button power latch arranged to control the primaries of the two power relays comprising B_8. When the spring-return button is depressed, the relays are activated and the button is by-passed by a connection through the contacts of the right-hand relay. A power failure opens both relays, and they remain deactivated even when power returns to the lines. After a power failure which breaks the vacuum, this arrangement prevents further heating which, in the presence of appreciable air, might disastrously oxidize the surfaces of the adiabatic jacket and shields.

Condensers C_1 and C_2 were put across the contacts of the power relays B_{10} and B_8 respectively, to overcome their tendency to "freeze" under the high self-inductive load of the Powerstats. Normally a battery charger operates the 6 v. D.C. safety circuit; but standby batteries take over in case of a power failure.

Operation

Preliminary measurements showed that the heat capacity of the adiabatic jacket is about 5,000 cal./deg. between 70 and 120°C. Over this interval heat leakage to the surroundings is only about 3 cal./deg.-min., so that 50 watts is sufficient to maintain a constant temperature. The temperature of the steel jacket is barely warm to the touch unless the vacuum is broken when it increases suddenly showing that heat losses by conduction predominate in this range. Mechanical failure of several heater windings showed up quickly during these preliminary experiments but the methods for the filling of the bombs, bleeding out liquid to maintain constant pressure, and keeping track of the solution level proved satisfactory.

Summary

A high-pressure calorimetric apparatus has been built to measure the heat capacities of aqueous solutions up to the critical temperature of water. Variable resistance heaters balance the temperature change of a bomb calorimeter containing solution against that of a similar tare calorimeter containing water. Thermal leakage to the surroundings is reduced by a vacuum jacket and radiation shields, while an automatic safety system guards against experimental hazards. The apparatus is described, and some information is given about its operation.

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Tin and Lead Complexes With 1,10-Phenanthroline[1]

WARREN W. BRANDT and E. ELAINE ZIMMERMAN, Purdue University

A search of the literature revealed that although very little work has been done on polyamine complexes of tin and lead, a few such compounds and complexes have been prepared. 1,10-Phenanthroline is known to form complexes with many metal ions. Since the order of stability of phenanthroline complexes differs from many other systems, it would be of interest to determine the position of the tin and lead complexes in this series. The complexes of Sn(II), Sn(IV) and Pb(II) with phenanthroline were therefore investigated.

Experimental

Qualitative evidence for complex formation was obtained in two ways. Both were indirect methods since the ions in question do not form colored complexes or insoluble precipitates with the phenanthroline. The first method which gave evidence for complex formation consisted in studying the behavior of the metallic ions with and without the reagent present. Their reactions with various anions were compared. Of 16 anions used, two (IO_4^- and I^-) gave different reactions with Sn(II) when phenanthroline was present than they did when it was absent. $S_2O_4^{-2}$ gave a difference with Sn(IV). $S_2O_3^{-2}$, $Fe(CN)_6^{-4}$ and SCN^- gave differences with Pb(II). These differences can be attributed to some type of interaction, presumably complexing, which had occurred between the metallic ion and the phenanthroline.

The second evidence that Sn(II), Sn(IV) and Pb(II) form complexes with phenanthroline was obtained from the fact that their presence caused a decrease in the intensity of the color of the ferroin complex in solution. The ferroin complex, the tris-1,10-phenanthroline iron(II) ion, has a reddish orange color with maximum absorbance at 510mμ. Part of the ferroin complex originally present was destroyed by the addition of stannous, stannic or plumbous ions. Apparently the interfering ions reacted with the trace of free phenanthroline which was in equilibrium with the ferroin complex. This caused more and more of the ferroin to dissociate until a new equilibrium was established which involved the tin- or lead-phenanthroline complex.

By letting ferrous and plumbous or stannic ions compete for a limited amount of phenanthroline in solution it was possible to calculate equilibrium constants and thus get some idea of the formulas of the tin- and lead-phenanthroline complexes. By comparison with ferroin it was also possible to calculate the dissociation constants of the complexes. Calculations were based upon absorbance values measured at 510mμ with a Beckman spectrophotometer-model B using 1 cm. cells.

The pH was a very important factor which had to be carefully controlled in order to get consistent results. In the range pH 4.5-8.0 the ferroin was satisfactorily stable. To eliminiate the possibility that variations in absorbance could be due to variations in pH, the pH of each series of test solutions was adjusted to within ± 0.1 pH unit. The pH was measured with a Beckman pH meter Model H-2. The pH of the Sn(IV)-phenanthroline solutions was adjusted by using ammonium hydroxide and hydrochloric acid. No satisfactory means of adjusting the pH of the Sn(II)-phenanthroline solutions to the desired value was found. The Sn(II) precipitated from solution almost quantitatively even at pH 3. Ammonium hydroxide and acetic acid were used to adjust the Pb(II)-phenanthroline solutions to the desired pH.

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[1] Abstracted from a thesis submitted by Elaine Zimmerman to the Graduate School, Purdue University, in partial fulfillment of the requirements for the Master of Science degree, 1953.

It was necessary to remove dissolved oxygen from the solutions by bubbling nitrogen through them. When the oxygen was removed a stable equilibrium was obtained. When oxygen was not removed there was a gradual decrease in the intensity of the color of the solutions on standing due to oxidation of the ferrous ions.

Calculations

The absorbance at 510mμ gave a measure of the amount of ferroin in the test solutions. Correction was made for the amount of the 1:1 ferrous-phenanthroline complex by using the formula derived by Kolthoff, et al. (2). The concentration of the 1:2 ferrous-phenanthroline complex was neglected because this complex is not stable in aqueous solutions. For the very dilute solutions used, approximately 10^{-4} molar, the activity coefficients were assumed to be the same for the complexed forms as for the uncomplexed forms. The phenanthroline not complexed with iron was assumed to be completely complexed with lead or tin. The values of the equilibrium constants were determined for the equilibria of the general type: Ferroin + stannic or plumbous ions $\rightleftarrows$ stannic or plumbous-phenanthroline complex + ferrous ions. The equilibrium constants were calculated assuming a 1:1, a 1:2 and a 1:3 ratio for the tin- and lead-phenanthroline complexes.

Assuming that only one of the three possible tin-phenanthroline complexes was formed in each case, the equilibrium constants for the reactions involving the 1:3, the 1:2, and the 1:1 complexes varied by factors of 35, 500 and 80 respectively. This seems to indicate that while the 1:3 complex was perhaps the major stannic-phenanthroline complex present, at least one or perhaps both of the other were also present. By assuming that both the 1:3 and the 1:1 complexes were present and using successive approximations, it was possible to obtain somewhat better constants. The equilibrium constants obtained by successive approximations agreed fairly well with those obtained assuming that the 1:1 complex was the major one in the solutions in which the tin to ferroin ratio was 15:1 and the 1:3 complex was the major one in the solutions in which the tin to ferroin ratio was 1:1 or 2:1.

By assuming that only one of the three possible plumbous phenanthroline complexes was formed in each case, the equilibrium constants obtained for the reactions involving the 1:3, the 1:2 and the 1:1 complexes varied by factors of 7, 20 and 2.8 respectively. The average value for the equilibrium constant for the reaction involving the 1:1 complex obtained from solutions in which the lead to ferroin ratio was 150:1 or higher and the average value for the equilibrium constant for the reaction involving the 1:3 complex obtained from solutions in which the lead to ferroin ratio was 10:1 or 20:1 were in fair agreement with the equilibrium constants obtained by assuming that both complexes were present and using the more laborious method of successive approximations.

The dissociation constant of ferroin has been reported by Cook and Long as 7×10^{-22} (1) and by Lee et al. as 5×10^{-22} (3). Knowing this and the equilibrium constants calculated above, the dissociation constants of the two tin-phenanthroline and the two lead-phenanthroline complexes can be calculated. The following dissociation constants were calculated: for the 1:3 stannic-phenanthroline complex, 5×10^{-20}; for the 1:1 stannic-phenanthroline complex, 8×10^{-7}; for the 1:3 plumbous-phenanthroline complex, 3×10^{-18}; for the 1:1 plumbous-phenanthroline complex, 2×10^{-5}. These values give an indication of the strength of the complexes, but they should be considered as only rather rough approximations of the true values. The 1:2 plumbous and stannic-phenanthroline complexes which may also be present in the solutions were disregarded in the calculations as were also any complexes between the metal ions and acetate, chloride and ammonia, which were added in adjusting the pH.

Conclusion

Since the tin- and lead-phenanthroline complexes are colorless as well as soluble in water, they do not afford a convenient method for the determination of tin or lead in solution. Both interfere in the colorimetric determination of ferrous iron using phenanthroline. Tin interferes seriously in the +4 oxidation state. Iron solutions to be determined by the phenanthroline method should, therefore, not be reduced using stannous chloride as the reducing agent.

Summary

Evidence was obtained for the formation of stannous- stannic- and plumbous-phenanthroline complexes. Approximate values of the dissociation constants of the 1:1 and 1:3 complexes of Sn(IV) and Pb(II) were calculated. The stannic-phenanthroline 1:3 complex is slightly weaker and the 1:1 complex is slightly stronger than the corresponding ferrous-phenanthroline complexes. The plumbous-phenanthroline complexes are weaker than either the stannic- or ferrous-phenanthroline complexes.

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Lithium Aluminum Hydride Reduction of Difluoroacetic Acid[1]

E. T. McBee, O. R. Pierce and C. G. Hsu, Purdue University

In earlier publications (2,8), alcohols are reported as the only products from the reaction between lithium aluminum hydride and carboxylic acids. However it was shown recently (5) that perfluoro acids can be reduced to perfluoro aldehydes by lithium aluminum hydride. The esters of perfluoro acids can be converted to the aldehydes by reduction with lithium aluminum hydride at Dry Ice temperature (10) and carbon dioxide has been reduced to methanol (3) or formaldehyde (9), depending on the amount of the hydride. It was of interest to study the reduction of difluoroacetic acid and to study the properties of difluoroacetaldehyde if formed, since this aldehyde can perhaps be used for the introduction of the CHF_2-group into various molecules.

Reduction of difluoroacetic acid with lithium aluminum hydride gave an 18% yield of difluoroacetaldehyde (27% when based on isolated 2,4-dinitrophenylhydrazone) and 12% of 2,2-difluoroethanol. Yields of isolated aldehyde are lower than derivatives because treatment with phosphorus pentoxide or sulfuric acid appears to result in polymerization and decomposition of the aldehyde. The mixture of aldehydrol and sulfuric acid decomposes when heated (above 118°), giving hydrogen fluoride and a black tar.

The yield of aldehyde in the reduction is increased by decreasing the quantity of lithium aluminum hydride. When a ratio of one-fourth of a mole of hydride per mole of acid is used, 20% of the unreacted acid is recovered. The yield of the aldehyde is increased to 34% (isolated as the 2,4-dinitrophenylhydrazone) but that of the alcohol is decreased to 2%.

A mechanism for reductions by lithium aluminum hydride has been postulated by Trevoy and Brown (12). They proposed that a hydride ion functions as a nucleophilic reagent in a bimolecular nucleophilic displacement reaction. This postulated mechanism may be used to explain the results obtained with difluoroacetic acid. The CHF_2- group causes the carbonyl carbon atom to be electron deficient; this not only permits an easier hydride attack but also makes it more difficult for an aluminate ion to leave. If the R group in the acid, RCOOH is changed to CF_3- or C_2F_5-, its electron withdrawing power is enhanced which results in a more stable ion and a greater formation of aldehydrol. This prediction agrees with the experimental results. The yield of perfluoroacetaldehyde and perfluoropropionaldehyde from acids is 46% (1) and 40-49% (7) respectively and substantially greater than that of difluoroacetaldehyde.

The structure of difluoroacetaldehyde was established by physical and chemical methods. Its infrared absorption spectrum shows the presence of bands characteristic of C-F (9.90-7.41 μ), C=O 5.65 μ) and C-H (3.5μ), but there are no bands for the OH group (3.22-2.68 μ) (4). In

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[1] The authors gratefully acknowledge the support of the Westinghouse Electric Corporation.

contrast to the aldehyde, the infrared absorption spectrum of aldehydrol exhibits the bands characteristic of C-F, C-H and OH groups but no bands for the C=O group. The aldehyde grouping is indicated by a positive Schiff's test and the formation of derivatives with semicarbazide hydrochloride and 2,4-dinitrophenylhydrazine. It reacts rapidly with water and acetic anhydride, yielding respectively difluoroacetaldehydrol and the diacetate of difluoroacetaldehydrol. This aldehydrol, unlike the solid perfluoro aldehydrols, is a liquid having a boiling point of 105.5-106°.

Further evidence for the typical carbonyl reactivity is obtained by the reaction of difluoroacetaldehyde with methylmagnesium iodide to give 1,1-difluoro-2-propanol in 53% yield.

Experimental[1]

Difluoroacetaldehyde.—Two pounds of anhydrous ether and 30 g. (0.8 mole) of lithium aluminum hydride were placed in a 2-l., 3-necked flask, fitted with a Hershberg stirrer, a 125 ml. dropping funnel and a reflux condenser protected by a calcium chloride tube. One mole (96 g.) of difluoroacetic acid was added dropwise from the dropping funnel to the stirred reaction mixture, which was cooled in an ice bath. The addition of the acid was kept at such a rate that the ether did not reflux. Upon completion of the addition of the acid, the mixture was stirred for two hours. The excess lithium aluminum hydride was destroyed by the cautious addition of 20 ml. of 95% ethanol and 20 ml. of water. The mixture was poured into a beaker containing 1 kg. of cracked ice and 200 ml. of concentrated sulfuric acid. The mixture was agitated well and the ether layer was separated. The aqueous layer was extracted three times with 200 ml. portions of ether. The ether layer and the ether extracts were distilled to remove the ether. An oily residue was obtained composed mainly of difluoroacetaldehydrol and 10 g. (12%) of 2,2-difluoroethanol. The oily residue was dried over Drierite and treated with phosphorus pentoxide. The aldehyde was distilled from the acid mixture directly into a cooled receiver (b.p. 31-43°). Redistillation through an eight-inch helix packed column yielded 14 g. (18%) of difluoroacetaldehyde, b.p. 27-28°. This aldehyde gave a positive Schiff's test.

Anal. Calcd. for $C_2H_2F_2O$: C, 30.00; H, 2.50. Found: C, 30.35; H, 2.85.

Difluoroacetaldehyde polymerized slowly either at room temperature or ice temperature to a white rubbery material. This polymerization was catalyzed by one drop of concentrated sulfuric acid, but was inhibited by very low temperatures. The aldehyde could be kept in the liquid state at Dry Ice temperature. The difluoroacetaldehyde polymer softens at 130° and starts to depolymerize at 165°. Solubility tests for this polymer indicate that it is soluble in acetone and insoluble in water, ethanol, butanol, chloroform, carbon tetrachloride, benzene and n-heptane. It swells in glacial acetic acid, ethyl acetate, methyl ethyl ketone, cyclohexanone and ether. It is also insoluble in cold dilute acid (10% hydrochloric acid) and cold dilute base (10% sodium hydroxide).

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[1] All temperatures are uncorrected; the melting points were determined with a Fischer-Johns melting point apparatus. Carbon, hydrogen and nitrogen analysis by H. Galbraith, Knoxville, Tennessee, and Mrs. C. S. T. Yeh of this department.

The **semicarbazone** of difluoroacetaldehyde was prepared following the method of Kling (6) with aqueous ethanol as solvent. The product was purified by two crystallizations from aqueous ethanol, m.p. 156-157°.

Anal. Calcd. for $C_3H_5F_2N_3O$: N, 30.65. Found: N, 30.86.

The **2,4-dinitrophenylhydrazone** was prepared according to the procedure of Shriner and Fuson (11). The orange-yellow needles were recrystallized from an ethanol-water mixture, m.p. 156-157°.

Anal. Calcd. for $C_8H_6F_2N_4O_4$: N, 21.54. Found: N, 21.69.

Difluoroacetaldehydrol.—Difluoroacetaldehyde (6.5 g., 0.081 mole) was placed in a 100 ml. flask equipped with a dropping funnel and a Dry Ice condenser. While shaking the flask, 1.4 g. (0.078 mole) of water was added dropwise. A reaction took place immediately with evolution of heat. After all the water was added, the flask was allowed to cool to room temperature. The resulting solution was distilled giving 4.6 g. (60%) of difluoroacetaldehydrol, b.p. 105.5-106°, n_D^{20} 1.3743.

Anal. Calcd. for $C_2H_4F_2O_2$: C, 24.49; H, 4.08. Found: C, 24.53; H, 4.22.

Diacetate of Difluoroacetaldehydrol.—In a 100 ml flask, fitted with a Dry Ice condenser, were placed 5 g. (0.063 mole) of difluoroacetaldehyde and 14 g. (0.137 mole) of acetic anhydride. One drop of concentrated sulfuric acid was added as a catalyst. The solution was refluxed for 15 min. and the product was recovered by washing with water, drying with anhydrous magnesium sulfate and rectifying. The yield of diacetate was 4.7 g. (41%), b.p. 176-178° (or 75°/13 mm.), n_D^{20} 1.3821.

Anal. Calcd. for $C_6H_8F_2O_4$: C, 39.56; H, 4.39. Found: C, 39.52; H, 4.52.

1,1-Difluoro-2-propanol.—Two-tenths of a mole (16 g.) of difluoroacetaldehyde in 100 ml. of anhydrous ether was added to an ether solution of a Grignard reagent, prepared from 6 g. (0.25 g. atom) of magnesium and 35.5 g. (0.25 mole) of methyl iodide, contained in a 3-necked, 300 ml. flask equipped with a stirrer, a dropping funnel and a reflux condenser. After the aldehyde solution was added, the mixture was allowed to stir for one hour and then poured onto cracked ice. The precipitate was dissolved in dilute (20%) sulfuric acid, the ether layer was separated and the aqueous layer was extracted three times with ether. The combined ether solutions were washed with a saturated sodium sulfite solution and dried over Drierite. Rectification yielded 10.1 g. (53%) of 1,1-difluoro-2-propanol, b.p. 93-93.5°, n_D^{20} 1.3494.

Anal. Calcd. for $C_3H_6F_2O$: C, 37.50; H, 6.24. Found: C, 37.39; H, 6.42.

Summary

Difluoroacetaldehyde has been prepared by the reduction of difluoroacetic acid with lithium aluminum hydride. Several reactions of this aldehyde were investigated and its infrared absorption spectrum has been determined.

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Studies of the Perfluoropropyl Grignard Reagent

E. T. McBee, A. F. Meiners and C. W. Roberts, Purdue University

It has been shown (1) that phenylmagnesium bromide reacts with heptafluoro-1-iodopropane to give n-heptafluoropropylmagnesium bromide according to the equation: $C_6H_5MgBr + C_3F_7I \rightarrow C_3F_7MgBr + C_6H_5I$. The preparation of the perfluoropropyl Grignard reagent by this method has the advantages over the direct method (2) of rapidity of preparation and high yield. This reaction was shown to be fast and complete at Dry Ice temperature by the inability to detect in the resulting mixture heptafluoro-1-iodopropane and the isolation of a 95% yield of iodobenzene only five minutes after mixing.

The reaction of n-heptafluoropropylmagnesium bromide with acetone was studied and 85% yields of the tertiary alcohol, 4,4,4,3,3,2,2-heptafluoro-2-methyl-2-pentanol, were obtained. The *aldol* by-products, diacetone alcohol and mesityl oxide, along with other condensation products, are also obtained (3). By preparing the perfluoropropyl Grignard reagent at Dry Ice temperatures, adding the acetone in ether at a fairly rapid rate, and then removing the cooling bath, allowing the reaction mixture to warm to room temperature rather quickly, the side reactions of aldolization and perfluoropropyl Grignard decomposition are minimized and excellent yields of the tertiary alcohol can be obtained. This reaction was used to determine the amount of n-heptafluoropropylmagnesium bromide present at a given time in a series of thermal stability studies.

In these experiments, the perfluoropropyl Grignard reagent was prepared initially at Dry Ice temperature and then held at the desired temperature by means of cyrostats. The reaction mixture was then treated with acetone according to the procedure outlined above. The results are summarized in the following table.

Temp. (°C)	Time (hr)	Yield (%)	% Decomposition
—70	0	85	0
—73	24	76	10.
—73	48	70	17.
—20	6	52	39
—20	12	43	49.
—20	24	33	61
+2	3	18	79
+2	6	6.5	92
+2	12	3	97

The marked influence of temperature on stability can be seen. The perfluoropropyl Grignard reagent is decomposed rapidly at 2°, 92% in 6 hours. It is more stable at —20°C., being 49% decomposed after 12 hours, but at Dry Ice temperature it is quite stable, being only 10% decomposed after 24 hours.

Support for this research by the Westinghouse Electric Corporation is gratefully acknowledged.

Experimental

The Reaction of Heptafluoro-1-iodopropane with Phenylmagnesium Bromide.

A 100 ml round-bottom flask, having a capillary tube and stopcock by means of which the contents could be drained, was equipped with a mercury-sealed Hershberg stirrer, a thermometer well and a closed-circuit addition funnel having a jacket by means of which the contents of the funnel could be cooled. After drying the apparatus carefully, the flask was cooled in a Dry Ice bath through which the capillary tube extended, and 50 ml of anhydrous ether and 7.67 g (0.0259 mole) of heptafluoro-1-iodopropane was placed in the flask. When the temperature of the flask was constant (—62°), 30 ml (0.032 mole) of 1.07 molar phenylmagnesium bromide, cooled to Dry Ice temperature, was added dropwise to the flask during 5 minutes, causing the temperature to rise to —50°. The reaction mixture was then immediately added to a stirred 10% solution of hydrochloric acid at 0°. The ether layer was separated, dried, and fractionally distilled. Ultraviolet spectra analysis of the material boiling below 40° indicated that no heptafluoro-1-iodopropane was present. To check the validity of this type of analysis a mixture of 10 g of iodobenzene, 100 ml of ether and 2-3 ml of a solution of heptafluoro-1-iodopropane in ether (2.5 g/100 ml) was fractionally distilled until no more low-boiling material was obtained. Ultraviolet analysis of this low-boiling mixture showed the characteristic maximum of heptafluoro-1-iodopropane at 257 μ. Thus it can be concluded that less than 1% of heptafluoro-1-iodopropane remained after a reaction time of only 5 minutes.

The Reaction of n-Heptafluoropropylmagnesium Bromide with Acetone.

A 500 ml round-bottom three-necked flask was equipped with a Tru-bore Hershberg stirrer, a closed circuit addition funnel, and a thermometer well. The apparatus was flamed out in a stream of dry nitrogen and subsequently cooled in a Dry Ice bath. Absolute ether (150 ml) and heptafluoro-1-iodopropane (29.6 g., 0.1 mole) were placed in the flask and phenylmagnesium bromide (100 ml, 1.07 molar) was added dropwise to the flask during 30 minutes. The temperature of the contents of the flask remain below —50°C. during the addition. Immediately after the addition of phenyl-magnesium bromide, 10 ml (7.9 g., 0.14 mole) of purified acetone in an equal volume of ether was added dropwise to the flask during 15 min. The Dry Ice bath was removed immediately after the addition of acetone, and the contents of the flask were allowed to come to room temperature. After stirring at room temperature for 4 hours, the mixture was cooled to 0° and hydrolyzed with 200 ml of 10% hydrochloric acid. The contents of the flask were allowed to stir for 1 hour; the ether layer was separated, the acid layer washed three times with ether, and the combined ether solutions were dried over Drierite. The acid layer gave a negative test for fluoride ion with cerous nitrate and zirconium-alizarine test solutions. The ether was partially distilled off through a 1 ft. glass helices-packed column, and the residue fractionally distilled through a Todd column. The material boiling between 71-120° weighed 21.1 g and was shown by infra-red spectra analysis to be 90% 4,4,4,3,3,2,2-heptafluoro-2-methyl-2-pentanol, representing an 85% yield.

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ENTOMOLOGY

Chairman: Paul T. Ulman, Noblesville

Donald W. Hamilton, Vincennes, was elected chairman for 1955.

ABSTRACTS

Notes on a Coleopterous Parasite of Beaver, *Platypsylla castoris*. John J. Favinger, Indiana Department of Conservation.—An effort was made by the author to ascertain if the coleopterous parasite of beaver, *Platypsylla castoris*, was introduced into Indiana at the time beaver were reintroduced from Michigan and Wisconsin in 1935, 1936, and 1937.

One specimen was obtained by beating a dried beaver pelt taken in the Kankakee area during the first open season on beaver since the reintroduction of the species to Indiana.

Since the initial collection in March, 1952, numerous specimens of *Platypsylla castoris* have been collected, from living beaver as well as from skins. At this writing the author has only adult specimens at hand but is interested in obtaining the larval forms and learning more of the life history of this curious parasitic beetle.

A Preliminary List of the Trichoptera of Tippecanoe County, Indiana. John M. Kingsolver, Indianapolis, Indiana.—A list was compiled of the Trichoptera of Tippecanoe County, Indiana. Thirty-four species are listed and include twelve new state records. Six new state records outside of Tippecanoe County are also listed.

Distribution of Three Important Insect Transmitted Tree Diseases

DONALD L. SCHUDER, Purdue University

The oaks and elms of Indiana are seriously threatened by the increasing spread of oak wilt, Dutch elm disease and phloem necrosis. These three insect borne diseases have been spreading throughout the state and no records are available to show their present occurrence. Three maps have been prepared which show the counties in which the diseases are known to occur. These maps were developed through observations, consultations and questionnaires of interested persons.

Dutch Elm Disease

Dutch elm disease is caused by the fungus *Ceratostomella ulmi,* the spores of which are spread from diseased to healthy trees through natural root grafts and by the feeding and burrowing of two species of bark beetles, the smaller European elm bark beetle, *Scolytus multistriatus* (March) and the less important native elm bark beetle, *Hylurgopinus rufipes* (Eichh.).

This disease has been present in Indiana since about 1937, but was limited in its occurrence to the general vicinity of Indianapolis. During the past few years, however, it has spread rapidly, so that it now occurs in at least 68 counties from the Ohio River to the Michigan state line. See figures 1 and 2. There are several causes for this spread. The population of bark beetles has increased enormously because of the many elms killed by Dutch elm disease and phloem necrosis. The droughty conditions of 1953 and 1954 weakened the elm trees and also made them more susceptible to the beetles, thus accelerating the spread of the disease.

There are three things which can be done to help control this disease.

(1) Keep the trees healthy and vigorous by proper fertilization and watering. Healthy trees are not as attractive to the bark beetles as are trees in a low state of vigor.

(2) All diseased trees should be removed and burned as soon as possible. If they cannot be removed they should be treated with a one per cent DDT solution or the bark removed. These practices will cut down the number of bark beetles and consequently the incidence of Dutch elm disease.

(3) All healthy trees should be sprayed with DDT so that the bark beetles will be killed before they can infect the still healthy trees. These sprays should be applied during the delayed dormant period (March and April) and again the last of July or the early part of August (7).

Phloem Necrosis

Phloem necrosis is a native virus disease which has been endemic in Indiana and neighboring states for many years. On the basis of available evidence it is thought the disease came into the state from Kentucky where elms had been dying since before the turn of the century. This virus disease is transmitted from diseased to healthy trees by the native white-banded elm leafhopper, *Scaphoideus luteolus* VanD. and through root grafts. At the present time elm trees in over half of the ninety-two counties in the state are infected with phloem necrosis with the heaviest infection being located in the central part of the state. See figure 3. The spread of phloem necrosis from diseased to healthy trees may be prevented by spraying twice a year with DDT emulsions since DDT kills the vector. The first spray is applied the last of May when the new leaves are formed and the second spray is applied the last of July (7).

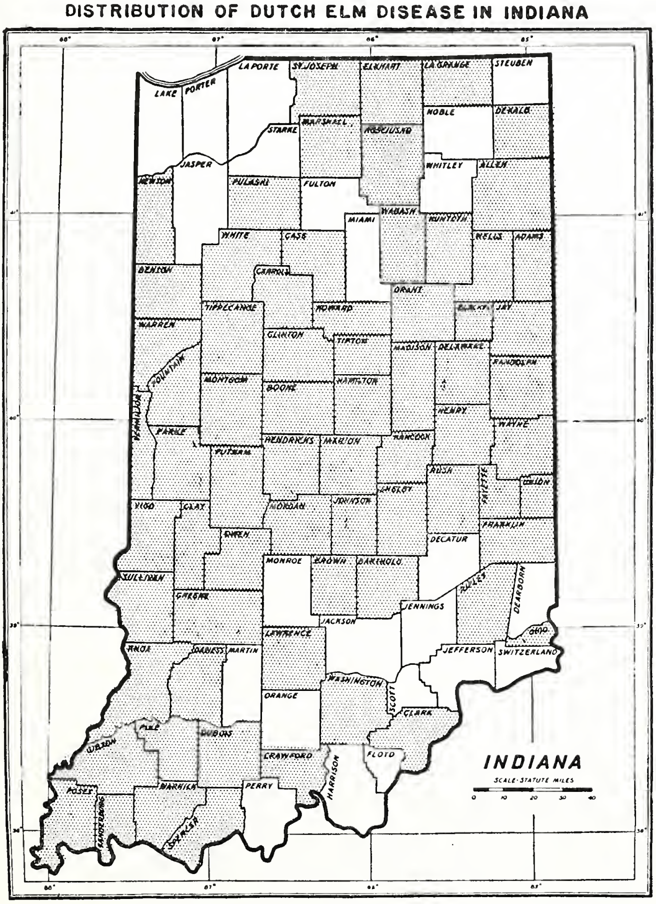

Figure 1. Distribution of Dutch elm disease in Indiana, 1954.
Infested counties indicated by black shading.

Oak Wilt

Oak wilt is caused by a fungus disease, *Endoconidiophora fagacearum* Bretz *(Chalara quercina)*. This is a disease which attacks red, black, white

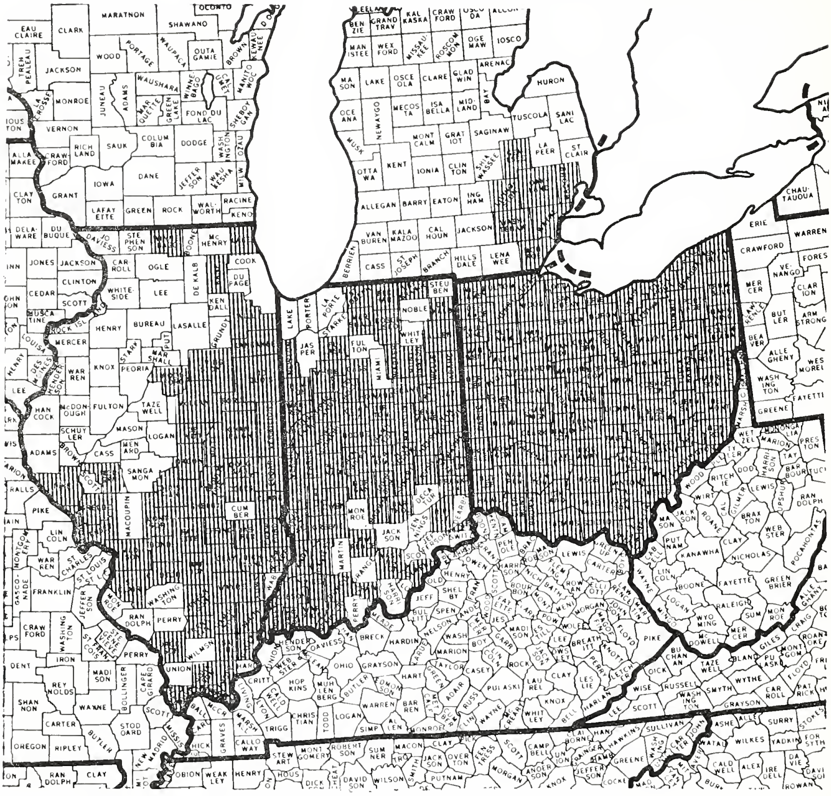

Figure 2. Distribution of Dutch elm disease in Indiana and neighboring states in 1954. Infested counties indicated by shading.

and burr oaks but is more severe in the first two groups. This disease first entered the state sometime before 1950 in the northwest corner of the state (2). Since that time the disease has spread rapidly south and east until it has now reached all borders of the state. See figure 4. Until recently the disease was known only to spread from tree to tree by natural root grafts. Now several workers, Dorsey, 1953; Himelick, 1954; and Norris, 1953, have found several species of insects which can experimentally transmit this disease from diseased to healthy trees. They are all species of sap beetles (Nitidulidae) found associated with the spore mats beneath the bark of diseased trees, such as: *Glishchrochilus sanquinolentus* Oliv., *G. fasiatus* ((Oliv.), *G. quadristignatus* (Say), *G. confluentus* Say, *Colopterus semitectus* Say, *C. truncatus* Rand, *Carpophilus lugubris* Murr, and *Epurea corticina* Erichs. In addition a species of oak bark beetle, *Psuedopityopthorus pruinosa* (Eichh.) and the pomace or fruitfly, *Drosophila melanogaster* Meig. have been indited by Griswold, 1953 and 1954. Nearly all of these insects require a break in the bark in order to successfully transmit the disease. One method of preventing the spread of this disease

DISTRIBUTION OF PHLOEM NECROSIS IN INDIANA

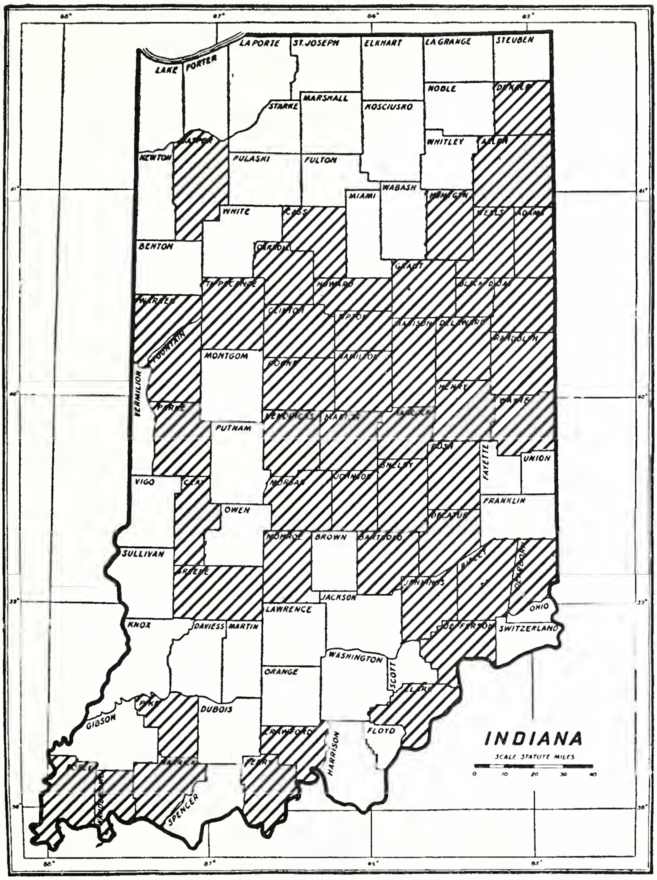

Figure 3. Distribution of phloem necrosis in Indiana in 1954. Infested counties indicated by shading.

is to avoid all wounds on oaks, especially in the months of April and May when translocation and spore germination are both very rapid. The other method of control consists of severing root connections between diseased and healthy oaks mechanically or by poisoning the surrounding trees with weed killers.

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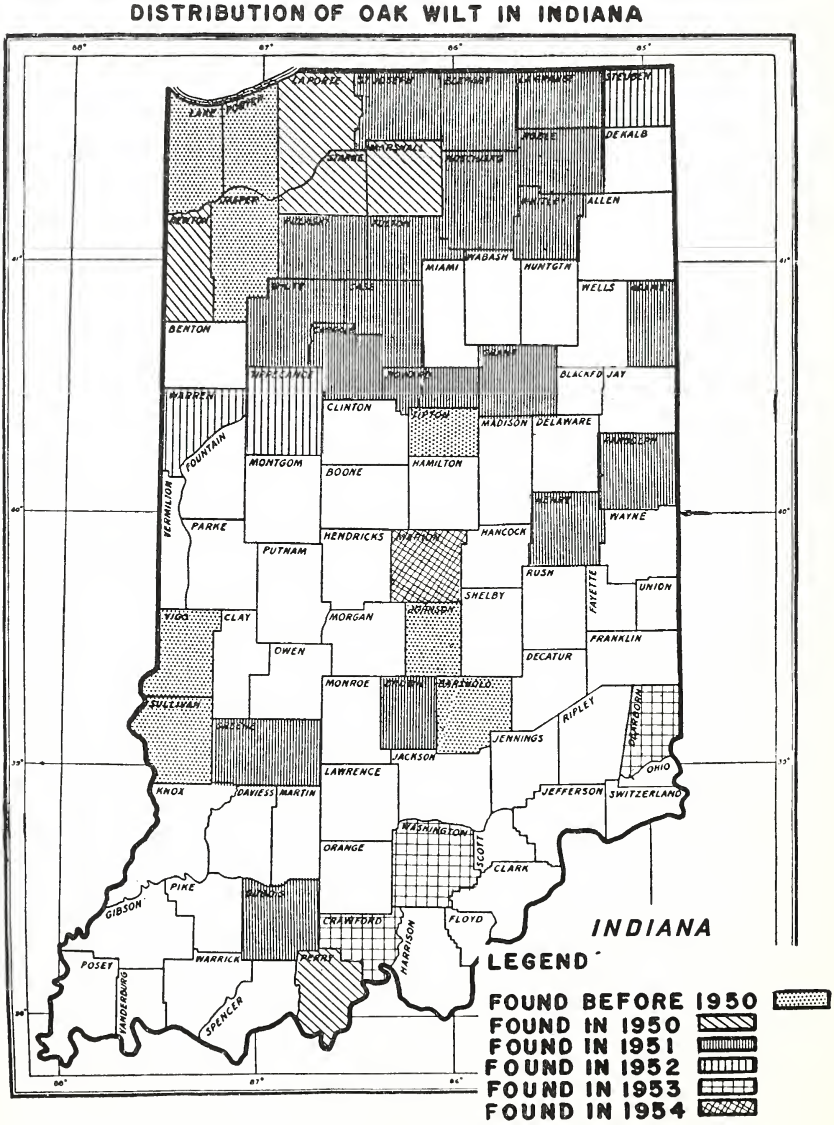

Figure 4. Distribution of oak wilt in Indiana. Various shadings indicate year the infestation was found.

Insects of Indiana in 1954

J. J. DAVIS, Purdue University

The weather for 1954 provided extremes of temperatures and rainfall which had a marked effect on the abundance of many economic species of insects.

For example, cool weather in the spring was responsible for army worm outbreaks, while dry weather later in the season indirectly affected damage by grasshoppers, webworms, and others.

The future of insect control is rapidly changing. It is generally recognized that many insect outbreaks can be predicted if we know the future weather. Further we know that the meteorological experts are now predicting 85 per cent correct the weather 30 days in advance. With this assurance we may anticipate reasonably accurate insect outbreak predictions.

That insect problems are major factors in agriculture is evidence by the fact that 35 per cent of calls to county agricultural agents during the growing season refer to insect problems.

Again there is a change in inquiries received by the Department of Entomology. In the past we have had a heavy correspondence on insect problems. Today, we still have a heavy mail correspondence but less than a few years ago. On the other hand, the telephone is the usual means of inquiry regarding insect problems. After all, insects are emergency problems and the telephone is a means of quick answers.

Another change is the availability of service work and in particular, the airplane; also ready availability of materials. Emergency needs, importance of quick service, and the low cost of insecticide applications by airplane have been responsible for an increasing use of the service airplane for insect control.

Field Crop Insects

Army worms *(Pseudaletia unipuncta)* were again very abundant. They were exceptionally abundant in 1953 and it is unusual to have army worm outbreaks two years in succession. The 1954 outbreak can be attributed to the cool spring weather, the same as in 1953, which permitted development of the worms, but was too cool to permit normal parasite development.

The first reports were from southern Indiana, early in May. At that time, most of the worms were small. Continuing into June damaging infestations developed throughout the state to the Michigan border. In many rye and wheat fields 50 per cent of the heads were cut off. Thousands of acres of pasture were cleaned of vegetation and it was sometimes difficult to find pasturage for feeder cattle. In many cases, migration from harvested grain fields resulted in heavy infestations in corn.

Thousands and perhaps millions of dollars damage was prevented by availability of insecticides and means of application. Many farmers now have low pressure spray equipment and there are now available many dependable airplane applicators who are doing good service work at a reasonable cost. It should also be noted that aerial applicators are acquainting themselves with the needs for insect control. They are certain to play a significant part in field crop insect control in the future. With the more general use of the newer insecticides and adequate ground and aerial equipment for application, at least $3,000,000 of crops were saved.

By the middle of June many reports were coming in from northern Indiana and several county agents reported 30 to 50 per cent of wheat destroyed.

The variegated cutworm *(Peridroma margaritosa)* appeared in unprecedented numbers, especially in southern Indiana, occurring the last half of May and into June. They were especially abundant on alfalfa and because of their climbing habit they were frequently mistaken for army worms. By early June, they were migrating into and damaging various adjoining crops. I do not recall this cutworm so abundant on field crops during the past forty years. During the latter part of August this cutworm was a serious pest eating into tomatoes.

Overflow or black cutworms *(Agrotis ypsilon)* were abundant in low spots in cornfields in many scattered places in the state, but not as severe as in 1953. The latter part of June the moths were exceptionally abundant and invaded homes where they were reported very annoying.

Grasshoppers (principally *Melanoplus femur-rubrum)* began appearing in threatening numbers the last of June. At that time, they were about a quarter inch long. They attacked all kinds of vegetation, including flowers and vegetables, but especially corn and legumes. The infestation was less in southern Indiana where the heaviest populations occurred in 1953, but northward, especially from Indianapolis north, there occurred very heavy populations, heavier than I have seen for 15 or 20 years. Sprays with low pressure ground sprayers and airplanes proved very effective and profitable.

The chinch bug *(Blissus leucopterus)* was abundant in hibernating quarters in eastern and western counties, north of Lafayette, Williamsport, and Richmond, in April. They were migrating into corn the latter part of June. Farmers had advance advice regarding controls and did an excellent job of preventing what otherwise may have been large losses.

The corn borer *(Pyrausta nubilalis)* wintered over in somewhat larger numbers than the winter before. The first moths appeared at Orleans May 23 and at Lafayette June 7. The more or less universal planting of corn after the recommended date prevented heavy infestations. Damage for 1954 will not be serious.

The sod webworm *(Crambus spp.)* caused extensive damage to corn in several areas early in June.

Garden webworm *(Loxostege similalis)* became very destructive to alfalfa in southern Indiana early in August. Because of the dry weather much of the earlier planted alfalfa died out, necessitating replanting. The new alfalfa was only three to six inches high by the middle of August and only a few worms were necessary to ruin the crop.

Seed corn beetle *(Agonoderus pallipes)* was abundant in a number of localities the last of May and first of June, but apparently was not doing much damage.

Grain aphids *(Macrosiphum granarium)* were reported abundant in heads of wheat from many places. All that we investigated were not doing appreciable damage.

Common stalk borer *(Papaipema nitela)* was common throughout the state, but especially central Indiana, during June, attacking wheat, corn, and certain vegetable crops.

The stem maggot *(Meromyza americana)* caused much loss to a large field of blue grass grown for seed.

Corn seed maggots *(Hylema cilicrura)* were reported damaging soybeans June 7 in a field following spring plowed rye. Following that report a number of cases (corn, beans, cantaloupes, etc.) were reported.

Flea beetles (principally *Chaetocnema pulicaria* and *Epitrix cucumeris)* were abundant generally on corn and potatoes. Stewart's disease followed infestations on corn.

The vetch bruchid *(Bruchus brachialis)* heavily infested vetch seed in several south central areas.

The alfalfa caterpillar *(Colias philodice eurytheme)* was abundant in many alfalfa fields.

Clover leaf weevil *(Hypera punctata)* was normally abundant in April and in some localities did noticeable damage.

Lesser clover leaf weevil or clover bud worm *(Hypera nigrirostris)* was common, infestations being rather general and in some cases 95 per cent of buds showed damage. The infestations occurred largely in northern Indiana and damage was largely to the first crop of clover.

The pea aphid *(Macrosiphum pisi)* built up to destructive numbers on alfalfa early in the season (April).

Alfalfa plant bug *(Adelphacoris lineolatus)* was conspicuously abundant at lights at Lafayette June 23.

Spittle bug *(Philaenus leucophtalmus)* began hatching at Lafayette April 9. Cool weather in May kept the developing bugs low on the plants. Adults appeared in southern Indiana the last of May, at Lafayette June 3 and were abundant in northern Indiana June 11. An interesting observation was made at Delphi the last of May where oats were heavily infested. In this particular field the wheat stubble of the year before, along with clover which was a poor stand, was disked leaving considerable litter which may have been responsible for abundance on oats. In general, more spraying was done and with excellent results.

Clover root borer *(Hylastinus obscurus)* was severe in some fields in northern Indiana, and in isolated fields the crop was completely destroyed.

Blister beetles (black, striped, and margined) *(Epicauta pennsylvanica, E. vittata* and *E. pestifera)* were generally abundant and destructive throughout the state. It might be noted that in Daviess County soybeans were defoliated in areas where grasshoppers had been abundant the past few years. Possibly this may be explained by the fact that in the larval stage, blister beetles are important, feeding on grasshopper eggs.

Green June beetle *(Cotinus nitida)* grubs were abundant in the spring throughout the southern part of the state, from Indianapolis south. In one instance they were very destructive by uprooting plants in hotbeds. Another notable case of damage was to a 1953 planting of alfalfa. This was a pasture field which had been heavily pastured for the previous five years. The beetles were unusually abundant during the season. In September, a report from southern Indiana indicated grubs very abundant on lawns, sidewalks, and streets following heavy rains.

Potato leafhopper *(Empoasca fabae)* has been especially abundant on alfalfa, snap beans and potatoes in the northern half of the state.

The green clover worm *(Plathypena scabra)* was abundant on soybeans and alfalfa in scattered locations.

The annual white grub *(Cyclocephala sp.)* has been very abundant and destructive to lawns this fall in northwestern Indiana.

Vegetable Garden Insects

The squash bug *(Anasa tristis)* built up to very large populations throughout the state by late August and early September, and has been responsible for heavy losses, especially in commercial plantings of squash and pumpkins. In Jackson County, for example, 20 per cent of the canning pumpkin acreage was disked up because of this insect and another 20 per cent was a total loss.

Rhubarb curculio *(Lixus concavus)* was damaging to rhubarb in many cases throughout the state.

Onion thrips *(Thrips tabaci)* were very severe on onions where no spraying was done.

Bean leaf beetle *(Cerotoma trifurcata)* caused considerable injury to soybeans in southern Indiana during the latter part of the season. In the truck garden area near Indianapolis, this species caused serious damage to pods and foliage of green beans and was especially serious adjacent to maturing soybeans. Early in the season, it was a pest of garden beans generally.

Twelve-spotted cucumber beetles *(Diabrotica 12-punctata)* were abundant and injuring pods of green beans and rind of squash early in September. Some commercial gardeners near Indianapolis were harvesting Hubbard squash early because of these beetles.

Corn ear worm *(Heliothis obsoleta)* adults first appeared at lights in Posey County May 25. It was a pest of corn, especially sweet corn, throughout the state. In commercial, as well as home plantings of tomatoes, it has been a real problem. In tomatoes it became especially serious and many commercial canning tomato plantings were abandoned because of the earworm. It has also damaged peppers, beans, and other vegetable crops late in the season.

Tomato hornworm *(Protoparce sexta)* was very abundant, especially in central Indiana, late in the season.

Tomato russet mite *(Vasates lycopersici)* had become a serious pest throughout Indiana and especially bad over the tomato canning producing area. Apparently does not winter over in Indiana and is brought into the state on plants from Tennessee and Georgia.

Cabbage worm *(Pieris rapae)* and cabbage looper *(Autographa brassicae)* were serious pests of cabbage and related crops throughout the state, but perhaps especially so in central Indiana, and late in the season.

Fruit Insects

Cherry fruit fly *(Rhagoletis cingulata)* was more abundant and widespread in northern Indiana than for several years.

The raspberry cane borer *(Oberea bimaculata)* has been reported from a number of localities throughout the state, although it is not a serious problem.

Insects of Shade Trees and Ornamentals

Cottony maple scale *(Pulvinaria vitus)* was very abundant in many parts of northern Indiana.

Forbes' scale *(Aspidiotus forbesi)* and Putnam's scale *(A. ancylus)* were rather common on shade trees in the Indianapolis area.

Juniper webworm *(Ypsolophus marginellus)* was very destructive to ornamental juniper plantings in many localities.

Sawflies are becoming major problems on pine plantings over the state. Most serious is the European pine sawfly *(Neodiprion sertifer)* which occurs in the northern half of the state and is especially destructive to Christmas tree plantings. The Jack pine sawfly *(N. americanus banksianae)* was common on Jack pine in the Indianapolis area. The short leaf pine sawfly *(N. americanus,* near *banksianae)* is common on short leaf pine plantings in southern Indiana.

European pine shoot moth *(Rhyacionia buoliana)* was generally abundant in the northern part of the state and especially on red pine in Christmas tree and reforestation plantings.

Elm leaf beetle *(Galerucella xanthomelaena)* was more generally abundant than I have ever known it to be in Indiana. It occurred throughout the southern half of the state. From reports Chinese elms were most severely attacked.

Bagworms *(Thyridopteryx ephemeraeformis)*, which were scarce in 1951 following years of abundance, are again building up to conspicuous and destructive numbers.

Black vine weevil *(Brachyrhinus sulcatus)* is becoming an increasingly important pest on Taxus.

Bronze birch borer *(Agrilus anxius)* has been reported frequently during the year, more than any previous year I can recall. This may be partly explained by the unusually dry years of 1953 and 1954.

The flat-headed maple borer *(Chrysobothris femorata)* was destructive generally over the state, more so than usual. Perhaps a major cause was the dry season of 1953 and again in 1954, which weakened the trees and made them susceptible to borer attack.

Household and Miscellaneous Pests

The little house fly *(Fannia canicularis)* was exceptionally abundant around poultry establishments in several sections of the state.

American dog ticks *(Dermacentor variabilis)* were commonly reported during May and June, from many parts of Indiana.

The brown dog tick *(Rhipicephalus sanguineus)* was reported from a number of localities during August and September, and in all cases the infestations were severe.

Chiggers *(Eutrombicula alfreddugesi)* were abundant in lawns according to the many reports received.

The damp wood termite *(Zootermopsis angusticollis)* was found in a consignment of lumber at South Bend, shipped from Broadbent, Oregon. The lumber was 2 x 4—8' green Douglas fir, anti-stain treated. Some fifteen pieces in the carload were infested. Although the damage was not great, Dr. T. E. Snyder advises us that this termite possibly could become established in our area, and might become a serious problem.

Fruit or vinegar flies *(Drosophila melanogaster)* were a serious problem in tomato canning plants, heavy infestations developing in the field because of the cracking of tomatoes before being picked.

Invading Pests

The clover mite *(Bryobia praetiosa)* was again a serious annoying pest, especially during April, migrating into homes from adjacent vegetation. As noted in last year's report, practically all reports were where new lawns occurred.

Click beetles *(Melanotus spp.)* were very abundant in an old home, vacant for eight years, and rehabilitated in June. The beetles were so abundant and annoying the first night of occupation, that the family got up and left the house in the early hours of the morning.

There are received annually many inquiries regarding such annoying pests as bees in walls of homes, wasps, hornets and yellow jackets.

The oats bug *(Anaphothrips striatus)* was annoying throughout the state the last of June. A great number of inquiries were received.

Elm leaf beetles *(Galerucella xanthomelaena)* were very abundant throughout the southern half of the state. By early September, reports of invasion into homes, where they are very annoying, were being received.

Box-elder bugs *(Leptocoris trivittatus)* continue as an annoying pest of first importance. This year they are not maturing uniformly and even the last of September we find the bugs in all stages of development.

Black widow spiders *(Latrodectus mactans)* were reported unusually abundant in several localities in southern Indiana.

Hackberry phyllids *(Pachypsylla celtedis mamma)* were again a conspicuous annoyance in homes.

Millipedes were reported invading homes this fall from all parts of the state.

Tarnished Plant Bug Injury to Peach[1]

MERRILL L. CLEVELAND, Purdue University

It has been known for some time that the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois, 1898), causes injury to peach. Much work has been done on the problem, but it seems that most of it has been concerned with injury to the fruit, known as cat-facing. It was believed that there was a need for a detailed study of the effects of the feeding of the tarnished plant bug on the flower buds, flowers, fruit buds, and very young fruit with special reference to the resultant dropping of these parts. The feeding habits of the insect indicated that the potential loss incurred by this early feeding would be greater than that incurred by feeding on larger fruits.

The tests were conducted on four Elberta peach trees located in the Purdue McCormick Tract Orchard near West Lafayette, Indiana, during the spring and summer of 1953.

In carrying out this experiment cages were placed over certain branches so that a given number of tarnished plant bugs could be introduced for a definite period of time and so that all other insects could be excluded. The cages were allowed to remain on the branches throughout the season. In an effort to protect the test insects as much as possible, no insecticides were applied to the test trees at any time during the experiment.

The cages, in which the peach branches were encased during the experiment, were constructed of 18 x 14 mesh bronze screen wire and cheesecloth. A cylinder was formed by stapling the opposite edges of a piece of screen wire to a piece of lightweight wood molding. The finished cylinder was nine inches long with a diameter of five and three-fourths inches. A cheesecloth sleeve ten inches long was attached to each end of the cylinder. After the cage was placed around the peach branch, it was secured by a length of heavy string.

The cages were placed on the peach branches on April 10 and on May 6. Those cages placed on the peach branches on April 10 were placed on three trees. They were so placed that each of the three cages used in a series of tests would be on a different tree, at a different height, and facing a different direction. Thus, when the results from the three cages were tabulated, the average obtained would not be overly influenced by conditions on a single tree, height, or relative position of the cages. After the cages were placed on the branches, each cage was labeled and designated for a specific test, with seven cages designated to remain insect free and serve as checks.

By the first part of May it became apparent that the cages would have to be placed on a fourth tree. This was necessary because some of the branches holding test cages had died while others had been blown down during storms. The branches of the fourth tree upon which cages were to be placed were thoroughly inspected for evidences of natural feeding of any insects, wind damage, or any other type of injury. Any damaged blossoms found were removed before the cages were attached.

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[1] This paper is based on a Master's thesis submitted at Purdue University in May, 1954.

The tarnished plant bugs used in these tests were collected with an insect net by sweeping the weeds and grass in the fields surrounding the orchard. For the most part, the insects were used in a test on the same day they were taken, but a reserve supply was maintained for use when inclement weather prevented the collection of insects. This reserve supply was kept in the orchard in a screen wire box nine and one-fourth inches by six and one-half inches. In an effort to keep conditions as natural as possible, pieces of sod containing plants from which the insects were taken were placed within the box. The supply of insects was changed every two to three days. The transfer of insects from net to cage was accomplished by means of an aspirator bottle.

In each test of the experiment five tarnished plant bugs were introduced into each of the test cages and left there for a period of two days. This experiment was concerned with the following tests: (1) one test during the pink to full bloom period, (2) four tests during the full bloom to petal fall period, (3) three tests during the petal fall to shuck split period, (4) four tests during the shuck split period, and (5) three tests after the shucks had dropped, here designated fruit tests.

The number of blossom buds, blossoms, fruit buds, or fruit in the cages were counted at the time the insects were introduced into the test cages, after the insects were removed from the cages, and at intervals of five to ten days for the remainder of the season.

The dates given in this work for pink, full-bloom, petal fall, shuck split, and shuck drop are the dates that these various stages were noted in the test cages concerned with that particular stage of development. Considering the orchard as a whole, there was a considerable variance in the date of the first appearance of these various stages. Broadly speaking, the pink stage started about April 10 and lasted until about April 25. The first full bloom was noted in the orchard on April 20 and the period lasted until about May 2. The petals began to fall April 27 and most of them were gone by May 7. The shuck split stage was noticed first on May 8 and continued until May 25 at which time all the shucks had fallen.

The natural population of tarnished plant bugs in the orchard seemed to be very sparse. No success was had when jarring methods were used, and only a very few individuals were taken when the grass in the center portion of the orchard was swept with an insect net. A few individuals were taken by sweeping the grass under the trees which were at the edges of the orchard. The tarnished plant bugs were plentiful, however, on the weeds, grass, and certain plants in the fields adjoining the peach orchard. No tarnished plant bugs were observed feeding naturally on the blossoms, fruit buds, or fruits of the test trees.

There was a low rate of mortality among those tarnished plant bugs which were used in the tests of this experiment, there being only five individuals lost out of the total number of insects used. No more than one insect was lost in any one test.

Results

The pink to full bloom test was begun on April 21 during the pink stage. A difference between the test and check cages in the per cent of drop of flower buds was noted within two days after the insects were introduced. There was a pronounced difference in the per cent of drop during the first 15 days; 78.4 per cent of the original flower buds in the test cages had dropped as compared to 40.2 per cent in the checks. The test indicated that the droppage which was due to tarnished plant bug feeding had ceased within 25 days after the insects were introduced. The results of the tests conducted in this experiment indicate that when tarnished plant bugs fed on peach during the pink to full bloom period, their feeding was responsible for a loss of 62.6 per cent of the potential crop.

The full bloom to petal fall tests were begun on April 23, 25, 27, and 29. In the four tests of this series the effects of the feeding of the tarnished plant bugs were noted within two to four days after the insects were introduced. Most of the drop which was due to the feeding of the insects was noted within a period of 13 to 26 days. The differences in per cent of drop between the test and check cages ranged from 26.5 per cent in Test D, to 27.0 per cent in Test B, to 32.0 per cent in Test C, to 51.2 per cent in Test A. When the feeding occurred during the full bloom to petal fall period, an average loss of 65.7 per cent of the potential crop was obtained.

The petal fall to shuck split tests were begun on May 1, 6, and 7. In the three tests of this series the effects of the feeding of the tarnished plant bugs were noted within one to seven days after the insects were introduced. The differences between the per cent of drop of fruit buds in the test cages and those in the check cages ranged from 44.7 in Test A, to 47.9 in Test B, to 74.4 in Test C. An average loss of 79.1 per cent of the potential crop was noted when the feeding occurred during the petal fall to shuck split period.

The shuck split tests were begun on May 8, 16, 17, and 21. In the four tests of this series the effects of the feeding of the tarnished plant bugs were noted within two days after the insects were introduced. Most of the drop which was due to the feeding of the insects was noted within a period of eight to fifteen days. The differences in per cent of drop between the test and check cages ranged from 10.7 per cent in Test A, to 18.7 per cent in Test B, to 34.7 per cent in Test D, to 44.7 per cent in Test C. When fed upon during the shuck split period, the potential crop was reduced by an average of 54.9 per cent.

The fruit test series consisted of three tests which were begun on May 23, 25, and 31. In this series no fruit droppage which was due to the feeding of the tarnished plant bug was noted. In each test the per cent of fruit drop in the check cages was as great as, or greater than, that in the test cages.

In no cage in which fruit remained at harvest time was there any evidence of cat-facing.

Conclusions

From the results obtained in this experiment, the following conclusions may be drawn:

1. That when the tarnished plant bug feeds upon the bloom and fruit of peach during the pink to full bloom, the full bloom to petal fall, the petal fall to shuck split, and, or the shuck split stage, it may cause from 55 to 80 per cent of the blossoms or fruit to drop.
2. That the feeding of the tarnished plant bug causes less drop during the shuck split stage than in the earlier stages.
3. That the feeding of the tarnished plant bug causes no significant fruit droppage when it occurs after the shucks have fallen.

Notes and Records of Indiana Odonata, 1953-54

B. Elwood Montgomery, Purdue University

There was less opportunity to observe and collect Odonata during 1953-1954 than in most previous years. However, 1,960 specimens of 71 species have been studied. One species not previously known from the state was taken and others recorded from Indiana only recently were observed to be well established.

The numbers of Williamson's 1917 list and the later interpolations (Williamson 1921, Montgomery 1925-1953) are used.

List of Collections Made During 1953-1954

(Arranged by counties and collecting stations; collections were made by the author unless otherwise noted.)

Boone. Sugar Creek, Rd. 52, June 22, 1953—species: 17, 18, 20, 21, 29, 43.

Cass. Lake Cicott, Sept. 10, 1953—species: 11, 13, 14, 30, 33, 34, 41, 43, 99, 105, 107, 111, 112, 114, 119, 124.

Clark. Bowen Lake, June 20, 1953—species: 20, 43, 58, 66, 90; June 27, 1954—species: 15, 20, 21, 22a, 29, 30, 41, 43, 44. Francke Lake, June 19, 1953—species: 115; June 26, 27, 1954—species: 10, 11, 33, 34, 41, 43, 44, 81, 89, 90, 119a. Schlamm Lake, June 19-21, 1953—species: 3, 10, 15, 20, 29, 33, 41, 43, 66, 96, 96a, 98, 99, 107, 108, 115, 119a, 120a; June 25-27, 1954—species: 10, 33, 34, 41, 43, 96, 98, 99, 107, 115, 119a, 120a. Stream flowing from Schlamm Lake, June 20-21, 1953—species: 3, 29, 48, 81, 94, 103, 107, 115; June 26, 1954—species: 3, 48, 96, 98, 108. Stream in State Forest flowing from a semi-open area, through woods—species: 41, 94, 107.

Clinton. Creek, Rd. 26, west of Middle Fork, Sept. 18, 1953—species: 4, 25.

Fulton. Fish hatchery ponds at Lake Manitou, July 23, 1953—species: 30, 41, 43, 99, 105, 107, 115, 118, 119, 120; Sept. 18, 1953—species: 22a, 24, 25, 30, 34, 43, 114, 124.

Gibson. Foote's Lake, July 11, 1953—species: 15, 34, 41, 63, 69, 80, 81, 98, 103, 104, 105, 107, 115. Lake, Oakland City, June 11, 1953—species: 20, 25, 34, 41, 43, 44, 81, 96, 104, 105, 107, 111, 115, 118, 124; July 12, 1953—species: 11, 22a, 43, 44, 96, 99, 105, 107, 114, 115, 118; Aug. 23, 1953—species: 13, 22a, 99, 100, 105, 108, 111, 112, 118; Sept. 5, 1954—species: 13, 25, 105, 108, 111. Pool along road near Oakland City, June 11, 1953—species: 7, 43, 44. Patoka River, N. of Princeton, June 11, 1953—species: 3, 18, 29, 43, 49, 104; July 12, 1953—species: 4, 15, 17, 18, 29, 41.

Johnson. Sugar Creek, Rd. 31, June 19, 1953—species: 3, 15, 18, 29; June 25, 1954—species: 4, 15, 16, 18, 20, 25, 29, 43.

Marshall. Open fields on Purdue Sand farm, July 23, 1953—species: 105, 119.

Ripley. Laughery Creek, Friendship, June 19, 1954, L. Chandler, collector—species: 29, 58. Farm pond near Friendship, Sept. 9, 1954, L. Chandler, collector—species: 110.

Starke. Hartz Lake, Sept. 10, 1954—species: 13, 14, 30, 33, 34, 41, 43, 107, 111, 112, 114. Tippecanoe River, Monterey, Sept. 10, 1953—species: 4, 17.

Tippecanoe. Hadley's Lake, July 26, 1953—species: 15, 43, 72, 99, 105, 112, 115; Sept. 11, 1953—species: 25, 105, 112; Sept. 16, 1954—species: 99, 111; Sept. 26, 1953—species: 41, 75, 110, 111, 112; Oct. 2, 1953—species: 110, 111; Oct. 12, 1953—species: 111, 114. Wabash River, N. of Lafayette, July 26, 1953—species: 3, 4, 15, 29, 52a, 115; Wabash River, 10-12 miles S. of Lafayette, Aug. 10, 1954—species: 15, 50, 52, 52a, 59b, 104; Aug. 13, 1954—species: 3, 15, 52, 52a, 59b. Tippecanoe River at Hog Point Bridge, July 23, 1954—species: 68; July 23, 1954—species: 68; July 26, 1954—species: 52a, 68. Flower gardens, Purdue Campus, Sept. 28, 1954—species: 13, 110, 111. Building, Purdue Campus, at night, June 26 and July 20, 1953—Chandler, collector—species: 70.

Warren. Kickapoo Creek, near mouth, four miles W. of Independence, Aug. 10, 1954—species: 3, 43, 52, 104.

Warrick. Lake, Boonville, May 30, 1953—species: 7, 20, 22, 22a, 25, 43.

Wells—Vanemon Swamp, July 8, 1954, BEM and Merrill Cleveland, collectors—species: 9, 11, 12, 104, 107, 112; Aug. 18, 1953, BEM and Kenneth Pruess, collectors—species: 9, 11, 13, 41, 43, 100, 107, 111, 112, 115.

White. Hoagland Ditch, S. of Monon, Sept. 10, 1954—species: 4, 17, 20.

List of Species Collected During 1953-1954

3. *Calopteryx maculata* Beauvois. Clark, Gibson, Johnson, Tippecanoe, Warren.

4. *Hetaerina americana* Fabricius. Clinton, Gibson, Johnson, Pulaski, Tippecanoe, White.

7. *Lestes disjunctus* Selys. Gibson, Warrick.

9. *Lestes forcipatus* Rambur. Wells.

10. *Lestes inaequalis* Walsh. Clark.

11. *Lestes rectangularis* Say. Cass, Clark, Gibson, Wells.

12. *Lestes dryas* Kirby. Wells.

13. *Lestes unguiculatus* Hagen. Cass, Fulton, Gibson, Starke, Tippecanoe, Wells.

14. *Lestes vigilax* Selys. Cass, Starke.

15. *Argia apicalis* (Say). Clark, Gibson, Johnson, Tippecanoe.

16. *Argia moesta* (Hagen). Johnson.

17. *Argia sedula* (Hagen). Boone, Gibson, Pulaski, White.

18. *Argia tibialis* (Rambur). Boone, Gibson, Johnson.

20. *Argia violacea* (Hagen). Boone, Clark, Gibson, Johnson, Warrick, White.

21. *Enallagma antennatum* (Say). Boone, Clark.

22. *Enallagma aspersum* (Hagen). Warrick.

22a. *Enallagma basidens* Calvert. Clark, Fulton, Gibson, Warrick.

24. *Enallagma carunculatum* Morse. Fulton.

25. *Enallagma civile* (Hagen). Clinton, Fulton, Gibson, Johnson, Tippecanoe, Warrick.

29. *Enallagma exsulans* (Hagen). Boone, Clark, Gibson, Johnson, Ripley, Tippecanoe.

30. *Enallagma geminatum* Kellicott. Cass, Clark, Fulton, Starke.

33. *Enallagma vesperum* Calvert. Cass, Clark, Starke. Although scattered specimens of this species may be taken in sheltered and shaded areas around lakes during the day, individuals begin to "swarm" over the water and in vegetation along the shore line at dusk—hence, the name given by Calvert to the species. The numbers flying appear to increase as the light decreases and just as it becomes too dark to see them any longer they are most abundant. On June 25-27, 1954, collecting trips were made along the shore of Schlamm Lake in the Clark County State Forest, beginning some time before sundown and continuing until after it was too dark to see an insect flying. On the first evening 13♂ and 12♀ were collected, on the second, only four of each sex and on the third day 15♂ and 13♀. The temperature was very high on the second day and did not drop noticeably at dusk as it did on the other two days. Thus, it appears that the flight pattern in this species may have some relationship to temperature.

In 1949 and 1950 I found *Lestes inaequalis* Walsh fairly abundant at Schlamm Lake, although it had not been seen there previously. It has been found each year since that time. It also occurs only in shaded areas during the day and begins to fly freely only near sundown although much earlier than *E. vesperum.* The numbers of this species taken on the three days in June followed the same pattern as *E. vesperum*—12♂ 3♀ on June 25, 6♂ 5♀ on the 26th and 11♂ 4♀ on the 27th.

34. *Enallagma signatum* (Hagen). Cass, Clark, Fulton, Gibson, Starke.

41. *Ischnura posita* (Hagen). Cass, Clark, Fulton, Gibson, Starke, Tippecanoe, Wells.

43. *Ischnura verticalis* (Say). Boone, Cass, Clark, Fulton, Gibson, Johnson, Starke, Tippecanoe, Warren, Warrick, Wells.

44. *Anomalagrion hastatum* (Say). Clark, Gibson, Tippecanoe.

45. *Tachopteryx thoreyi* (Hagen). Tippecanoe; a female of this species is included in a 4-H club insect collection made by David F. Pfendler. It was taken "resting on a tree," in a yard, on the edge of a ravine, about 7 miles west of West Lafayette.

48. *Cordulegaster obliquus* (Say). Clark. This species appears to be increasing in numbers in the State Forest, especially along the stream flowing from Schlamm Lake. The intermittent overflow, maintaining a moist bed in the stream with occasional pools, but usually no continuous flow of water in the summer would appear to be very favorable for this species. Seventeen males and one female were taken in 1953, but only one male in 1954, although others were seen.

49. *Progomphus obscurus* (Rambur). Gibson.

50. *Hagenius brevistylus* Selys. Tippecanoe.

52. *Erpetogomphus designatus* (Hagen). Tippecanoe, Warren.

52a. *Stylurus amnicola* (Walsh). Tippecanoe.

52b. *Stylurus plagiatus* (Selys). Tippecanoe.

58. *Gomphus graslinellus* Walsh. Clark, Ripley.

63. *Gomphus submedianus* Williamson. Gibson.

64. *Gomphus vastus* Walsh. Tippecanoe.

66. *Gomphus villosipes* Selys. Clark.

68. *Dromogomphus spinosus* Selys. Tippecanoe.

69. *Dromogomphus spoliatus* (Hagen). Clark, Gibson.

70. *Boyeria vinosa* (Say). Tippecanoe.

72. *Anax junior* (Drury). Tippecanoe.

75. *Aeshna constricta* Say. Clark, Tippecanoe.

78. *Aeshna umbrosa* Walker. Tippecanoe.

80. *Nasiaeschna pentacantha* (Rambur). Gibson.

81. *Epiaeschna heros* (Fabricius). Clark.

87. *Epicordulia princeps* (Hagen). Clark, Gibson.

*88a. * *Neurocordulia yamaskansis* (Provancher). Tippecanoe; Purdue Electric farm, about 5 miles north of West Lafayette, June 20, 1953, experimental light trap—1 ♀. This is the first record of this species, and the second for the genus, in Indiana. Say recorded *N. obsoleta* from the state, in a paper written sometime before 1834, but not published until 1839, five years after his death. This specimen is referred to *yamaskansis* rather than to *obsoleta* on the basis of general characters—especially the form of the vulvar lamina and the light coloration of the wings. (The specific differentials of the species of the genus are not very distinct and have never received exhaustive study.) There are only traces of brown at the bases of both fore and rear wings, and a brownish border to the subnodus and the subcostal antenodals (all 4 or 5 in rear wings, but only the proximal five—of seven—in the fore wing) with no color at all beyond the nodus.

Walker (1915) has recorded the flight habits of this species ". . . their time of flight is limited to about half an hour a day, commencing soon after sundown (a little after 8 p. m.), and continuing until shortly after 8:30, after which they retire to the shelter of the trees. It is thus nearly coincident with the mayflies, *Ephemera*, *Hexagenia*, *Heptagenia*, etc., upon which they appear to feed exclusively." The present specimen was taken in a "suction" light trap; no notes are available to indicate if mayflies were taken on the same date, but the specimen was very likely trapped while pursuing prey attracted to the light.

Two other specimens of Odonata, both females, were also taken in light traps in 1953—one of *P. tenera* at the same locality, July 18, and one of *S. ambiguum* near Vincennes, Aug. 8.

89. *Tetragoneuria cynosura* (Say). Clark.

90. *Tetragoneuria cynosura simulans* Muttkowski. Clark, Tippecanoe.

94. *Somatochlora linearis* (Hagen). Clark.

96. *Holotania cyanea* (Fabricius). Clark, Gibson.

98. *Holotania incesta* (Hagen). Clark, Gibson.

99. *Holotania luctuosa* (Burmeister). Cass, Clark, Fulton, Gibson, Tippecanoe.

103. *Holotania vibrans* (Fabricius). Clark, Gibson.

96a. *Ladona deplanata* (Rambur). Clark. This species, first taken at Schlamm Lake, in 1952, was found in 1953 (5 ♂ 1 ♀), but not in 1954.

100. *Neotetrum pulchellum* (Drury). Gibson, Wells.

104. *Plathemis lydia* (Drury). Gibson, Tippecanoe, Warren, Wells.

105. *Perithemis tenera* (Say). Cass, Fulton, Gibson, Marshall, Tippecanoe.

107. *Erythemis simplicicollis* (Say). Cass, Clark, Fulton, Gibson, Starke, Tippecanoe, Wells. Specimens taken at Schlamm Lake, June 20, 1953, seem worthy of note. Of 6♂ 5♀ taken, 1♂ was lightly and 4♀ were heavily infested with mites. One male is the smallest specimen of this species I have ever seen—length, 35 mm., abdomen 24 mm., fore wing 27 mm., and rear wing 26 mm., other specimens were of normal size, two representative males, measuring: length 42-43 mm., abdomen 29 mm., fore wing 31 mm., and rear wing 30 mm.

108. *Sympetrum ambiguum* (Rambur). Clark, Knox, Gibson, Tippecanoe.

110. *Sympetrum internum* Montgomery. Ripley, Tippecanoe.

111. *Sympetrum obtrusum* (Hagen). Cass, Gibson, Starke, Tippecanoe, Wells.

112. *Sympetrum rubicundulum* (Say). Cass, Gibson, Starke, Tippecanoe, Wells.

114. *Sympetrum vicinum* (Hagen). Cass, Fulton, Gibson, Starke, Tippecanoe.

115. *Pachydiplax longipennis* (Burmeister). Clark, Gibson, Tippecanoe, Wells.

118. *Celithemis elisa* (Hagen). Fulton, Gibson.

119. *Celithemis eponina* (Drury). Cass, Fulton, Marshall.

119a. *Celithemis fasciata* Kirby. Clark.

120. *Celithemis monomelaena* Williamson. Fulton.

120a. *Celithemis verna* Pritchard. Clark. This species was first found in the state at Schlamm Lake in 1949; it was noted in 1950, but not in 1951 or 1952. However, it now appears to be well established at this locality, and was observed and collected in 1953 (13♂ 2♀, including two mated pairs) and 1954 (5♂ 2♀, including two mated pairs).

124. *Tramea lacerata* Hagen. Cass, Fulton, Gibson.

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The Effect of Rain and Applications of Fungicides and Insecticides on the Catfacing of Strawberries

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Strawberries which are distorted, which ripen unevenly or have irregularly spaced seeds when the fruits are ripe, are said to be "catfaced." For the purpose of this study, all fruits which had any disfigurement to prevent them from being U. S. Number 1 grade, with the exception of size, rot or chewing insect damage were included in the category. During a portion of the harvest period in some years, as many as 45 per cent of the berries are catfaced.

Figure 1 shows the extent of catfacing in 1952 and 1953 crops. The periods of heaviest distortion do not occur at the same time each year.

In an attempt to find the most important cause of catfacing, 19 plots have been used for sprays and observation. The crop on each of these has been counted and graded and these results are made up from a record of 126,605 berries. In addition, the study included blooms tagged to determine the length of the period between the time the bloom opens and the ripening of the berry therefrom, the effects of rot organisms found growing in newly opened blooms, and the effects of thrips on the blooms.

Aside from leads developing through this project, from time to time different workers in the field have mentioned several prime causes of catfacing. Those affording the greatest probabilities and concerning which little is known are:

1. Feeding by tarnished plant bugs.
2. The role of thrips and leaf rollers.
3. The effects of frost injury.
4. The extent to which rot organisms cause malformation of the berries.
5. The extent to which rain effects berry growth.

1. Over a period of four years feeding on strawberry fruits or blooms by the tarnished plant bug, *Lygus lineolaris*, has never been observed here. However, since claims have been made that they catface berries our studies have given consideration to the control of this insect, one which has pretty largely defied control in peaches. However, Anderson et al. (1) using DDT obtained excellent results in control on alfalfa grown for seed production. These plant bugs feed on and damage many plants and as a single example of the type of injury they do might be cited in Weaver and Olson's (5) article on the control of Lygus bugs in chrysanthemum production with DDT. Sabadilla, a material most effective in the control of Lygus bugs, stink bugs and other plant bugs was used in southern Indiana in nine dust applications during bloom. Figure 3 shows that the reduction in catfacing, brought about by such numerous dust applications, was not practical. This is another indication that tarnished plant bugs damage berries but little, if any.

2. Daily counts of thrips *(Frankliniella tritici)* and *(F. fusca)* activity, show that while a few thrips are present early in the season, there is a tremendous increase in population beginning about a week after the

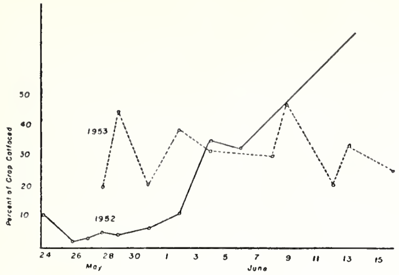

Figure 1. Percent of crop catfaced on each picking date from untreated plantings of Cremal strawberries.

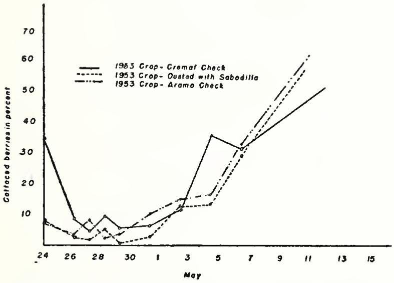

Figure 3. The effects of 9 sabadilla dusts applied during strawberry bloom period to control catfacing.

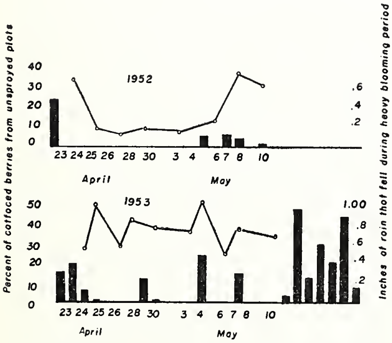

Figure 5. The relationship between rainfall at blooming time and catfaced berries at harvest for 1952 and 1953. Black bars represent the amount of rain during bloom period. Black lines represent the percentage of catfaced berries and are placed in correct position above bars to show how much rain fell on the blooms which produced the percentages of catfaced berries shown.

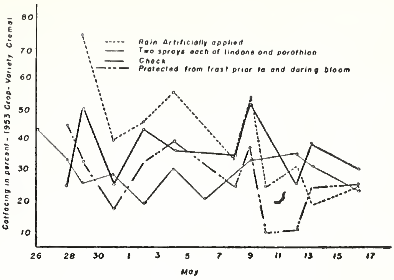

Figure 2. Effects of rain, sprays and frost on the catfacing of strawberries.

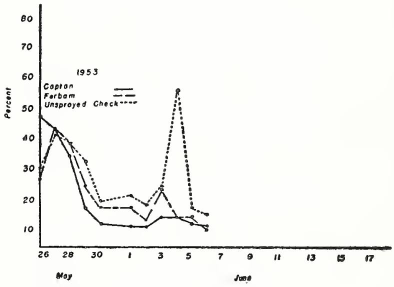

Figure 4. Percentage of catfaced berries in Aroma for every picking day of the 1953 season.

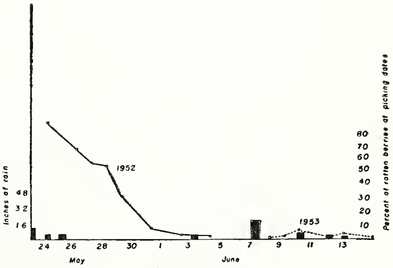

Figure 6. Rains and the incidence of rot in Cremal strawberries during picking season at Orleans. Black columns represent rainfall and amount during picking season in 1952. Barred column represents the only rain that fell during picking season in 1953. Black line represents the amount of rot in 1952. Dotted line represents amount of rot in 1953.

first blooms open, and continuing until late in the blossom period. This build-up coincides with the hatch of the strawberry leaf roller, *Ancylis comptana fragariae.* Since both these insects enter the blossom buds before they open, there is some basis for the belief that during the last of the blooming period, when the population is highest, these species and thrips in particular, not only catface more fruits than at any other time, but also prevent setting of the berries. Observation has proven that the leaf roller causes malformed berries though the only point proven about thrips is that they prevent berry setting. Nevertheless the two species probably account for some of the increase in catfacing which sometimes takes place at the last of the picking season. Two sprays each, of lindane and parathion, were applied alternately during bloom and spaced to cover that period. After these sprays, no leaf roller larvae could be found. These four sprays did not eliminate thrips, though they did reduce them to small numbers. Ewart and Elmer (2) reported excellent control of fruit scarring caused by thrips on oranges and lemons by the use of two sprays containing ½ lb. of actual dieldrin per acre. Kauffman and Stevenson (3) found that although three or four well timed sprays of toxaphene on cotton did not eliminate thrips, such applications did result in an increase of almost 500 pounds of seed cotton per acre. Though results were based on population counts rather than crop data, of several materials used, Parencia and Cowan (4) report the best control by spraying with toxaphene. Figure 2 of this work shows that two sprays each of lindane and parathion as measured by a reduction in catfacing, was probably worth the effort and reduced the amount of catfacing 10 to 15 per cent over much of the picking season.

3. In an attempt to determine whether or not frost may injure or catface strawberries, beginning at the time the blossom buds were growing out of the crown, a row was covered by a roof set on sides eight inches high. Each night this covering was placed over the berries and each day it was removed. This prevented exposure of the plants to frost and freezing temperatures; Figure 2 shows that this was of little use as a preventative for catfacing.

4. Fungus growths were observed to develop at the base of the receptacle in some newly opened blooms. In many cases, the stamens, pistils, and often some of the sepals were affected. These blooms were tagged and the berries developing from them were observed periodically. Usually such berries grow with an indentation or crease in the sides of the berry because when some of the flower parts are destroyed, pollination is not complete, seeds fail to develop, and the resulting fruits are misshapen. Following attacks of the flower parts by fungus, in many instances, rot developed as these berries were ripening. If this is the condition that leads to catfaced berries the blooms of which were attacked by rot, it is reasonable to assume that so few blooms would be thus injured and later affected by fungus as to be of no consequence in the total crop. However, a series of quadruplicated plots of approximately 1/120 acre each were sprayed with Captan and Ferbam for control of diseases. Three sprays were put on (May 1, 11 and 21), the first at the time the first blooms were opening, the second 10 days later, and the last 10 days after the second. As shown in figure 4

this treatment resulted in a reduction in the number of catfaced berries.

5. The question of rain in the catfacing of strawberries was a lead which developed through our strawberry irrigation work at this station. Its effects were discovered quite by accident after a row of berries in bloom had been watered every day (by use of a sprinkling system) to determine whether or not such a practice would result in an increase in rot development. As harvest counts were taken, the effects of water on the catfacing of berries became quite evident. Later studies in which water was dripped on the newly opened blooms at intervals of approximately five minutes proved that such blooms will not develop normally, if at all. Figure 1 shows that the period of heaviest catfacing does not occur at the same time each year. This graph poses the question as to the cause of the difference in the time of the most catfacing with respect to the picking season. Figure 5 comes as near answering this question as any that might be prepared. It shows for 1952 and 1953 the amount of rainfall that occurred during the heavy blooming period and how each heavy rain resulted in an increase in catfacing at ripening time. On the other hand figure 6 shows that rain during ripening time has very little effect on catfacing.

Figure 2 shows how heavy the catfacing can be made to be when rainfall is artificially applied. The untreated check plots were second in the number of catfaced berries as compared with those receiving artificial rain. The plots which received four insecticide applications during the blooming period produced a crop relatively low in catfaced berries. The plot protected from frost produced only a few catfaced berries but this may be because the covering which protected the plots from frost also prevented any rain from falling on the blooms. Figure 4 shows the effects of three sprays of Captan and Ferbam applied during the blooming period in reducing the number of catfaced berries. Ferbam, however, impairs the quality of the ripened fruit and should not be used commercially. Reference has been made earlier to figure 3 which shows the effects of nine Sabadilla dusts in the reduction of catfacing. Thus, from our studies to date, it appears that rainfall may cause the greatest amount of catfacing whereas on years when the population of leaf roller and thrips is heavy, they may cause a considerable amount of crop damage. Rot organisms appear not to be as important as either of these other factors. Nevertheless, aside from rotted berries which are a total loss, rot organisms may cause considerable catfacing in wet years or during years or in patches where the incidence of rot is great, and by reference to figure 4, it would seem that fungus control reduced catfacing as much as 12 to 15 per cent.

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A SYMPOSIUM ON A CENTURY OF ENTOMOLOGY IN INDIANA

Moderator, Ray T. Everly

(a) Introduction..Ray T. Everly
(b) Entomology Before 1854........................B. E. Montgomery
(c) Entomological Pioneers in Indiana..................M. C. Wilson
(d) Entomology at Purdue................................H. O. Deay
(e) Regulatory Entomology in Indiana...................P. T. Ulman
(f) Federal Entomology in Indiana............Phillip Luginbill, Sr.
(g) Work at Other Institutions and by Private Individuals
Since 1854...F. N. Young
(h) The Field of Entomology—Its Past, Its Present,
Its Future...J. J. Davis

Introduction

Ray T. Everly

This year entomologists in the United States are recognizing the 100th anniversary of economic entomology as a profession in this country. In 1854 Townsend Glover was appointed to the U. S. Patent Office as entomologist. His duties were to prepare exhibits of insects, seeds, and plants and fruits. In addition he did research on insects attacking orange trees and cotton. The same year Asa Fitch was appointed as a full-time entomologist by New York State. He studied life histories and habits of insects especially those injurious to vegetation in New York. His research laid the groundwork for further development of entomology.

Since the appointment of these two men to full-time study of insect problems in 1854, the science of entomology has made an expansion and development equalled by few other sciences. Prior to 1854, entomology was largely a hobby of wealthy individuals and persons in other professions, who spent their spare time making collections and working out the taxonomy and philogeny of insect groups. This work was important as it laid the foundation of the knowledge required to identify the injurious insects that are our problems today. Today entomology as a profession is followed by some 6,500 men and women in the United States.

This rapid development of entomology in the United States was due to many causes. The influx of emigrants and the import of plant materials brought many insect immigrants which, relieved of restrictive environmental controls, became major problems in this country. The application of mass methods of production to our food and other raw materials set up ideal conditions for certain insects to multiply in great numbers. Increased standards of living and increases in population has made necessary increased protective measures for our food sources, as well as those of our fiber crops. Advertising has made people aware of imperfections of raw foods and has thus brought the demand that our fruit, vegetables, and packaged goods be free of imperfections and insects.

Greater concentrations of populations, and the penetration of man into areas where certain insect-borne diseases are epidemic has necessitated intensive study of the control of those insects that affect our health. All in all, insects today play a greater and more important part in our lives than ever before in the history of man.

The development of entomology in our country was paralleled by that in Indiana. All those causes that contributed to increased need for insect control in the U. S. were present in this state. Lying in the eastern edge of the rich midwest, Indiana was among the first to feel the influence of migrations, increasing populations, and the increased production of food and other products. Thus as these speakers bring to you the picture of entomology in the Hoosier State, they will give to you a good picture of what occurred generally throughout the United States.

Entomology Before 1854

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It is the purpose of this introductory paper to discuss the status of insects and the history of Entomology before 1854, excluding any reference to Indiana which will be the subject of the second paper. As it is obviously impossible to cover the history of Entomology to 1854, even in the most cursory manner, within a reasonable time, I shall confine my remarks to two small and unrelated segments of this history. First, I shall examine briefly the place insects occupied in the life of ancient peoples, chiefly by a review of the references to insects in the Bible.[1] Then, I shall try to summarize the condition of economic entomology in America before 1854 by means of some tabulations of the papers published on the subject and of the insects mentioned.

Howard (1930) indicated that insects were little noticed and of little importance before the Revolutionary War:

"The crops of the early colonists in America apparently did not suffer seriously from the attacks of insects. The growth of agriculture was relatively slow. The opportunities for the introduction of new insects from other countries were practically non-existent. Apparently very few native insects changed their habits and took to cultivated crops."

Furthermore, he implied that insects received very little attention until long after 1854:

"It is interesting to note that from 1771 until 1880 there were only 60 men in the whole of North America who wrote worth-while notes or articles on injurious insects. Between 1771 and the outbreak of the Civil War there were only 23 such writers."

A contemporary observer also indicated that the colonists were little interested in scientific matters. Pehr Kalm, the Finnish naturalist who traveled in America during 1748-1751, while in French Canada, recorded in his diary on July 2nd, 1749:

"I found that the people of distinction had here in general a much greater taste for natural history and other learning than in the English colonies, where it was everybody's sole care and employment to scrape a fortune together, and where the sciences were held in universal contempt." However, Foster, the translator of the 1770 English edition of Kalm's travelogue, included a footnote, with a vigorous denial, "One need only cast an eye on Dr. Linne's new edition of his *Systema* . . . in order to be convinced that the English in America have contributed a greater share towards promoting natural history, than any nation under heaven, and certainly more than the French, though their learned men are often handsomely pensioned by their great Monarque: on the other hand the English study that branch of knowledge, from the sole motive of its utility." (Benson, 1937.)

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[1] The portion of the discussion dealing with insects in ancient times will be published elsewhere.

Kalm was able to assemble a very considerable amount of information about the natural history of the colonies, much of it gleaned from the colonists in spite of his opinion of their interest in the subject. His observations on insects were rather extensive and give us some idea of their importance in colonial life.

On December 9, 1748, writing his diary at Philadelphia, he recorded observations and information on a number of pests, including the 17-year cicada, caterpillars defoliating trees, "grass-worms" (army worms?), clothes moths, fleas, crickets, bedbugs, cockroaches and mosquitoes. Kalm was greatly impressed by the damage caused by the pea weevil, stating that peas were no longer cultivated in Pennsylvania, and to only a very limited extent in New Jersey and New York because of the damage by this pest.

About a century before Kalm's voyage to America, John Josselyn, an Englishman, had spent some time in this country on two trips, 1638-39 and 1663-71, and, in the account of his travels published in 1672, noted certain pests (Felter 1927). These included ticks, bedbugs, mosquitoes, black flies and deer flies.

Slingerland and Crosby (1924) quote a certain John Hull as recording in 1661, that "the cankerworm hath for four years devoured most of the apples in Boston, so that the trees look in June as if it were the ninth month."

Baird (1917) has traced some early outbreaks of the forest tent caterpillar, finding that Smith and Abbott, in 1797, reported it "sometimes so plentiful in Virginia as to strip the oak trees bare," and that there was a similar outbreak, probably of the same insect, in Vermont in 1791.

Parker (1954) refers to an early outbreak of grasshoppers. "In 1740 grasshoppers attacked the scanty crops of the Massachusetts Colony. The colonists armed themselves with bundles of brush, and drove millions into the ocean."

With the expansion of Agriculture, insects attacking garden and field crops also received attention, beginning about the time of the Revolutionary War. This interest increased gradually at first, but expanded rather rapidly with the extension of settlement westward, the introduction of new crops, the increase of commerce bringing new pests. A considerable number of men, mostly farmers or fruit growers, ministers, physicians, or teachers, had their attention drawn to insect problems and recorded their observations. Before the appointment of Fitch and Glover to official positions in 1854, several men who can rightly be called entomologists joined this group of writers.

The first paper on economic entomology to be published in America seems to have been one on the Angoumois grain moth by Colonel Langdon Carter in 1771.

The man who may be called the father of American economic entomology was William D. Peck, professor at Harvard College. He published his first paper on injurious insects, an article entitled "The Description and History of the Cankerworm," in 1795. He was the author of five more papers from 1799 to 1819, discussing the slugworm, the cankerworm again, insects attacking the twigs of pear and pine, borers in locust, and, finally, the oak pruner and plum curculio.

Thomas Say, the great systematic entomologist, published papers on the Hessian fly, the peach tree borer and the cotton caterpillar.

T. W. Harris published his first paper (on the salt marsh caterpillar) in 1823 and continued to write until 1860, publishing 93 papers. Miss Margarette H. Morris published on entomological subjects from 1841 until 1860, writing 23 papers; Howard (1930) considered "Her writings . . . popular and not very well founded, although she was looked upon at the time as an authority."

To show the extent to which economic entomology had received attention at the time of the appointment of the first "official" entomologists I have tabulated the number of papers dated 1854 or earlier which are listed in "The Bibliography of American Economic Entomology" (Henshaw 1895, 1896). I find that 258 papers by 102 different authors are listed. Of these, 11 papers by ten authors were published before 1800, four by four authors from 1801 to 1810 inclusive, 24 by 18 authors from 1811 to 1820, 42 by 18 authors from 1821 to 1830, 32 by 22 authors from 1831 to 1840, 46 by 19 authors from 1841 to 1845, 74 by 28 authors from 1846 to 1850, and 53 by 12 authors from 1851 to 1854 (14 by seven authors during 1854).

In the papers published from 1771 to 1840 inclusive 48 injurious insects or groups of insects are discussed. (One paper published in 1762 and said to discuss the "cochineal insects that breed on the *Cactus opuntia* or Indian fig in South Carolina and Georgia" is listed in the Bibliography.) The ones mentioned most frequently are cankerworms to which there are 20 references (three each before 1800 and from 1811 to 1820, five from 1821 to 1830 and nine from 1831 to 1840), the Hessian fly with 13 references (four each before 1800 and from 1811 to 1820, two from 1821 to 1830 and one between 1831 and 1840) and the seventeen-year cicada with seven references (two during 1811-20, three 1821-30, two 1831-40). Six insects are listed five times each: armyworms (one each 1801-10 and 1811-20 and two 1831-40), cutworms (three 1811-20, one each 1821-30 and 1831-40), the wheat jointworm (four 1811-20, two 1821-30, one 1831-40), the rose chafer (all during 1821-30), the plum curculio (one 1801-10, two each 1811-20 and 1821-30), and bark beetles (two 1811-20, three 1821-30), and four others four times each: the Angoumois grain moth (before 1800, 1811-20, 1821-30, 1831-40), the locust borer (one 1811-20, two 1821-30, one 1831-40), the peach tree borer (one 1801-10, two 1811-20, one 1821-30), and the sheep botfly (all during 1811-20). Six insects received attention in three papers each—cotton leaf worm (21-3)[2], tent caterpillars (11-1, 21-2), flat-headed apple tree borer (11-1, 21-2), round-headed apple tree borer (21-2, 31-1), leaf beetles on tree (31-2), and sheep tick (11-3), and in two papers each—grasshoppers (01-1, 31-1), wireworms (11-1, 31-1), oyster shell scale (01-1, 11-1), unidentified scales (21-2), woolly apple aphid (21-2), white pine weevil (11-1, 21-1), scarab leaf chafers (21-2), grape vine flea beetle (31-2), and the bee moth (31-2). Twenty insects were each mentioned once only in these papers: before 1800—a sawfly on beech and willow, 1811-20—codling moth, oak twig pruner and carpenter worm, 1821-30—white grubs, salt marsh caterpillar, pigeon tremex, fall webworm, apple worm, pear borer, pear slug, imported currant borer, squash vine borer, pea weevil, cabbage maggot, turnip butterfly, larder beetle and horse bot, 1831-40—chinch bug and antique tussock moth.

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[2] In these tabulations the frequency of mention in each of the four periods, 1801-10, 1811-21, 1821-30 and 1831-40, is indicated following the initial years of the periods.

Webster (1892) has given us a summary of some of the early observations on insects, especially those attacking field crops. He warns entomologists that they must be careful in reporting observations as "new" since some early writer may have already described the insect and its damage and/or published figures. John Josselyn gave rather accurate descriptions of the appearance and the damage caused by white grubs. Jacob Cist, in 1824, published an illustration of a fungus parasite of this insect. In 1822, James Worth published descriptions of damage to wheat by several insects including the joint worm and the wheat stem maggot, and of aphids feeding on the roots of wheat, corn and young trees. In 1829, a Thomas Emory discussed an aphid affecting wheat noting, "I believe this insect is the same as that known by the name of the root-louse in corn, so frequently found in that plant," indicating that this insect was well-known at that time. Rather complete descriptions of the symptoms of Hessian-fly infested wheat and illustrations of several stages of this insect were published in 1822, and quite surprisingly, late sowing was recommended as a preventive measure against this insect in 1799.

In 1841, T. W. Harris published the first edition of his book on injurious insects under the title, "Report on Insects Injurious to Vegetation." It was reprinted the following year and a revised edition was published in 1852.[3] This work included compilations of most of the available information on all the important plant pests, and included remedial suggestions. However, Howard (1930) who reviewed the control recommendations for 50 such pests thought "Doctor Harris was not by taste an *economic* entomologist. . . . he did not know agriculture, apparently, except for occasional reading, . . . and he introduced, I think, no new ideas as to remedies." Nevertheless, the time from 1841 to 1854 may be considered, I believe, a period of "semi-official" entomology. Harris' book was "prepared and published by the Commissioners on the Zoological and Botanical Survey of Massachusetts, agreeably to an order of the General Court, and at the expense of the State." Furthermore, he received pay from the State for this work. (The sum of $175.00!) Also from that date more and more of the literature on insects and insect damage came from the hands of professional entomologists. In addition to numerous entries under the names of Harris and Morris, new and familiar names as LeBaron, Fitch, etc., appear in the Bibliography.

Although most of the serious introduced pests of garden, orchard and field probably reached this country after 1854, many pests had already been brought from Europe. Most of the grain and stored products pests, household insects and animal parasites probably arrived with the early colonists and their possessions. Kalm stated in 1749 that "*The common houseflies* were observed in this country about 150 years ago as I have been assured by several persons in this town (Montreal) and in Quebec." There are definite records of the Hessian fly, codling moth, pear slug and pea weevil before 1800 and of the diamond black moth, cabbage maggot, pear psylla, imported currant worm and elm leaf beetle between 1800 and 1850.

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[3] The edition most common is the revision by Flint published in 1862. It is stated that "No alterations have been made in the author's language, and the additional notes are enclosed in brackets to distinguish them from those in the former editions." However, the "wood engraving which themselves marked an epoch in that art" (Howard 1930) were new.

Two fields of economic entomology, apiculture and sericulture, were not considered in Howard's History and papers in these subjects were not listed in Henshaw's Bibliography.

The development of beekeeping in this country may be said to be somewhat parallel with that of economic entomology. A real revolution in beekeeping occurred at almost the same time as the beginning of official entomology. The honeybee was apparently introduced into Massachusetts in early colonial days but until about 1853 the beekeeping methods in use did not differ materially from those used in the Old World for centuries. In 1851 Langstroth discovered the "bee space" and invented the modern hive based on this principle. About this time Quinby, using primitive equipment (without smoker or movable frame hive) made honey production profitable by developing methods of obtaining the honey without destroying the bees. J. E. Hetherington (later Captain and also reputed to be the world's most extensive honey producer of his time) began beekeeping in 1852 at the age of twelve years. In 1853, L. L. Langstroth, "the Father of American (or Modern) Beekeeping," published his "Hive and the Honeybee" and Moses Quinby, "Father of Commercial Beekeeping," published "The Mysteries of Beekeeping Explained," entirely independently of each other. The principles set forth in these two books provided an almost explosive expansion of beekeeping. Three years later Quinby and his associates produced for the market ten tons of boxed honey and created a sensation which rocked the beekeeping world (and glutted the New York honey market!). In another two years, Hetherington, now seventeen, was selling his honey by the ton and building up apiary holdings which were, eventually, to reach 3,000 colonies.

Sericulture was also introduced into America by the early colonists, but in spite of many waves of enthusiasm, it never established itself on a firm basis anywhere. One of the waves of great interest in silk production was moving through the eastern states for several years after 1830. An examination of several issues of a silk culture journal[4] published during 1835 reveals that societies were being formed in counties and cities throughout the northeastern states, that there was a silk factory of considerable size in Hartford and others being constructed elsewhere, and that people in almost every walk of life were taking up the production of silk. However, this movement had apparently almost subsided by 1854, only to be repeated at intervals for the next fifty or more years, especially in California where the first recommendation for state assistance in the production of silk was made in 1855.

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[4] *The Silk Culturist and Farmer's Manual,* "published monthly by the Executive Committee of the Hartford County Silk Society at Hartford, Conn."

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Entomological Pioneers in Indiana

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The need of professional entomologists to study economic insect problems and to devise methods of controlling insects was evident in the early days of Indiana history although public funds were not available until the latter part of the nineteenth century. Man, living in the modern era of today, may on occasion be annoyed by insects, but science and technology has so greatly alleviated insect problems that he finds it difficult to visualize the gravity of uncontrolled insects as they existed a century ago. Without doubt many disease epidemics, the cause of which was unknown, were carried by insects which raged uncontrolled throughout vermin-infested houses and stagnation created by lack of sanitation and poor sewage facilities.

It is interesting to note that in *Indiana as Seen by Early Travelers*, visitors to the state in the early nineteenth century were so annoyed by pestiferous forms, or were so impressed by the magnitude of insect damage, that they included them in their reports. Bedbugs were a frequent annoyance as David Thomas reported in 1819. Even though his host, when Thomas stopped for the night, extended hospitality, it couldn't be enjoyed because he suffered sleepless nights due to the bugs.

Thomas Scattergood Teas, reporting on his trip to Fort Wayne, in 1821, told of spending a night in "continual warfare with myriads of fleas." "I was compelled to retreat from the field, or rather bed of battle, about two hours from daybreak and got a little sleep in a chair." It is quite possible that the fleas referred to were another case of bedbugs.

William Corbett in 1828 reported arriving at Louisville, but on observing stagnant waters about the town and the appearance of vermin-infested houses did not stay overnight.

Teas also found the mosquitoes and gnats as numerous as along the seashore. They were so abundant in the woods that it was impossible to find drinking water in a pool that was not filled with mosquito larvae, and on stopping to rest one had to kindle a fire and sit in the smoke for protection against the insects.

Mosquitoes were such a continual annoyance that William Pelham noticed their decline when cold weather set in and wrote in 1825, "This coldness of the air silenced the musicians who have so diligently amused the inhabitants of this town ever since I have been here. I mean certain little winged insects who take care to indemnify themselves for any trouble they are at to entertain us, by piercing the skin and drawing off the superfluous moisture."

These mosquitoes which the early travelers in Indiana complained of were more than an annoyance. Some of them were the vectors of malaria and yellow fever. Williams, 1941, pointed out that in 1882 malaria was endemic in the area southeast of the Appalachians and as far north as

Long Island. West of the mountains the endemic area extended to the Canadian border. In southern Indiana the disease was of frequent occurrence. However, by 1912 the endemic area extended no farther north than southern Indiana and there was largely confined to a narrow strip along the Ohio River.

Yellow fever reached epidemic status several times in early American history. There are records of outbreaks on ships and in the eastern seaport cities of Philadelphia and New York. According to Sawyer, 1943, yellow fever swept up the Mississippi to Memphis and beyond and probably many cases occurred in the Ohio Valley in southern Indiana.

Early travelers to Indiana not only noticed an abundance of insects that were annoying to man, but were impressed by the pests that damaged crops. David Thomas observed the destruction of meadows and the killing of corn twice in a season on a 1,000-acre farm by armyworms. The problem became so acute that ingenious farmers devised a mechanical control whereby deep furrows were plowed in which logs were constantly drawn by horses, so long as the armies of caterpillars continued to approach. Such a method was tedious and took a great deal of time, but thousands of the destructive worms were killed and crops were saved.

Early methods of applied insect control in agriculture were largely mechanical. Many of the early economic entomologists were men of wide agricultural background who had a keen perception of the farm but little or no formal training in entomology. However, they contributed greatly to economic entomology by developing mechanical controls and other techniques that could be best applied in the farm program. The log drawn by a horse is symbolic of the beginning of crop insect control. From it, as experience and knowledge have expanded, other methods have evolved.

At Vincennes in 1816 Thomas was impressed by what he called a "curious fly flapper." It was a mechanical device to drive the flies away. He described it as follows:

"The construction is simple, and in hot weather, the fresh air that attends its motion, is scarcely less agreeable than relief from these troublesome insects. Its position is over the center of the table.

"Two strips of lath three feet long, with a hole in the lower end of each to receive a gudgeon, are first prepared. A broad board with a gudgeon so placed in each end, that one edge shall always preponderate, is then connected with the strips. To that edge a piece of linen one foot wide is fastened; and a handle, eighteen inches long, projects from the opposite edge. The upper ends of the laths are then nailed at the ceiling, and a small cord attached to the handle communicates motion to the instrument."

These early observations made by visitors to Indiana over a century ago illustrate that the need for professional entomologists existed for many years before public funds were allocated to that purpose.

The year 1854 is historically significant to entomologists because it was the first date that a state legislature set aside funds for the study and control of insects. In a sense, because this act involved public funds and for the first time provided a vocation for the insect specialist, it was the beginning of entomology as a profession. Heretofore, the entomologist's only remuneration was the personal satisfaction one might obtain from the pursuit of any avocation.

However, to entomologists the year 1854 is not synonymous with the beginning of entomology as a science, particularly in Indiana. The science of entomology actually had its birth in the Hoosier State a quarter century earlier when in 1826 Thomas Say came to Indiana. He was a member of the expedition of scientists known as "The Boatload of Knowledge" who founded the historical New Harmony settlement.

As a scientist, Thomas Say has been called the "Father of American Entomology" and has been recognized as one of the greatest of zoologists and naturalists. More specifically, Say was a taxonomist and in the short period of eight years in Indiana, until his untimely death at the age of 47, he described many species of insects. Davis (1932) estimated that Say described more than 1,000 species of beetles plus over 400 insects of other orders. He found that Say listed 404 new insect species from Indiana and that not less than 10 per cent of the 250 most important Indiana pests were described by Say.

Recognition of the insect is fundamental in insect control and it cannot be overlooked in economic entomology. Knowledge of the morphological characteristics of the insect as well as its biology and habits are necessary before control measures can be determined. Therefore, in the truest sense, economic entomology began not with the employment of the first state entomologist, but with Thomas Say, the naturalist, who a quarter century prior to 1854 made fundamental studies that were basic to the control studies that came later.

It is indeed unfortunate that the young State of Indiana and the young science of entomology should lose Thomas Say in the prime of his life. As has been pointed out, Say's contributions to Indiana entomology during a brief eight years were tremendous. However, he died 16 years before the first professional entomologist was appointed in the United States and 50 years before entomology was established in Indiana at Purdue University.

In the half century between Say's death and the arrival of F. M. Webster in Indiana as Special Agent of the U. S. Department of Agriculture and Consulting Entomologist for the Purdue University Agricultural Experiment Station, little entomological progress was made in the state. During that period the only entomological contributions were the collections compiled and biological notes made by a few men who enjoyed entomology as an avocation in their spare time.

It seems probable that professional entomology would have had an earlier beginning and would have made significantly great contributions in Indiana prior to 1884 had Say lived. Certainly Say, himself, would have added a great deal more to our knowledge of insects. It is also reasonable to presume that a man of Say's stature would have had influence to spur legislative interest in the importance of insects and the need for study and control.

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Entomology at Purdue

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Purdue University is the Land Grant College of Indiana and was established under the provisions of the Morrill Act of July 2, 1862. The Indiana legislature accepted the grant in 1865. The site and name (Purdue University) were selected for the proposed college in 1869. The first president, Doctor Richard Owen, was elected in 1872 and the first students were admitted in 1874 (7).[1]

Entomology was provided for in the first plans made for the University. It is of interest to note (1) that of the 30 books which comprised the University library in 1874, four dealt with insects. These were: Harris' "Insects Injurious to Vegetation," Packard's "Guide to the Study of Insects," Langstroth's "The Honey Bee," and Quinby's "Mysteries of Bee Keeping."

Entomologists at Purdue have participated in the four principal fields of entomology: teaching, research, regulatory, and extension.

Teaching

In the first course of study published by Purdue (1) five courses in entomology were included. A two-hour course entitled "Entomology" was included in the second year and a course, "Management of Bees," in the third year of the Full Course in Agriculture and Horticulture; a two-hour course "Zoology—Insects Useful and Injurious" was included in the second year of the Special Course in Agriculture; and a two-hour course "Entomology" in the second year and a five-hour course "Relation of Entomology and Botany" in the fourth year of the Course in Natural History. This first course of study was evidently planned by Doctor Richard Owen, as he was the only member of the faculty up to 1874.

Despite the fact that entomology courses were listed in the Course of Study for the years 1874-1879, there were no formal classes in entomology taught until the spring of 1880, for it was not until the fall of 1879 (4) that the first students enrolled in the School of Agriculture and Horticulture. All students in the school at that time were required to take a six-weeks course in entomology in the third term of the first year. As Professor Charles L. Ingersoll was the sole instructor in the School of Agriculture and Horticulture at that time, he would be the first to teach a class in entomology at Purdue. Professor W. C. Latta, who succeeded Professor Ingersoll, probably taught classes in entomology during the school years 1882-83 and 1883-84.

The real teaching in entomology at Purdue began in 1884 when James Troop was added to the staff of the School of Agriculture and Horticulture with the title of Professor of Horticulture and Entomology. Professor Troop was born in New York in 1853 and received a B.S. degree from Michigan State College in 1878 and a M.S. degree from that institution in 1882. He also did graduate work in entomology at Cornell and Harvard.

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[1] Numbers in Parentheses refer to Literature Cited.

When the Department of Horticulture was organized, Professor Troop became its first head and in 1912 when the Department of Entomology was organized he became its first head. Although Professor J. J. Davis succeeded him as head of the Department in 1920, Professor Troop continued his teaching until 1929 and was on the staff as professor emeritus at the time of his death in 1941. At the time of his appointment there was but one course offered in entomology. This number had been increased to five by the time he retired as head of the department in 1920.

Mr. Jesse G. Boyle, an instructor in Horticulture, taught the beginning course in entomology from 1910 to 1912. P. W. Mason was appointed Instructor in Entomology and Assistant in Entomology in the Agricultural Experiment Station in 1912. He held these positions until 1918. W. A. Price joined the teaching staff of the Department in 1914 and remained at Purdue until 1929 when he resigned to accept the position as head of the Entomology Department at the University of Kentucky.

In 1920 John J. Davis succeeded Professor Troop as Head of the Department, which position he now holds. Professor Davis was graduated from the University of Illinois in 1907. Before coming to Purdue he had been employed by the Illinois Natural History Survey and by the Bureau of Entomology of the U. S. Department of Agriculture. He had charge of the U. S. Cereal and Forage Insect Laboratory at West Lafayette from 1913 until 1919. In 1919-1920 he had charge of the Japanese Beetle investigations for the Bureau of Entomology at Riverton, New Jersey. His principal research activities up to the time he came to Purdue had been with greenhouse insects, aphids, white grubs, the Japanese beetle, the Hessian fly, and cutworms. Under Professor Davis' leadership, instruction in entomology has expanded until Purdue is now recognized as being one of the leading centers of entomological education.

Until 1928 the Department of Entomology (5) was solely a service department, providing instruction in entomology for students specializing in the various fields of Agriculture. In 1928 a curriculum was provided for students who wished to major in entomology. A second curriculum was set up in 1946 at the demand of the Pest Control Operators of the United States and Canada to provide a four-year course of instruction for students who wish to become Commercial Pest Control Operators. Therefore, at present the Department administers two undergraduate curricula, one called Entomology and the other Structural Pest Control, which lead to a B.S. in Agriculture degree. Besides this the Department offers graduate study which leads to the degrees of Master of Science and Doctor of Philosophy. At present 31 courses are offered by the Department on the University campus and one each at the Purdue Extension Centers at Fort Wayne and Indianapolis.

Up to the present, 86 students majoring in entomology have earned a Bachelor of Science in Agriculture degree, 27 a Master of Science degree, and four the Doctor of Philosophy degree. Of the 86 students who received their undergraduate degrees in entomology at Purdue 38 have gone on to do graduate work. Twenty-seven of these have earned Master of Science degrees, one a Doctor of Medicine degree, and four the Doctor of Philosophy degree.

The present members of the teaching staff are: L. Chandler, instructor; M. L. Cleveland, graduate assistant; J. J. Davis, professor and head; H. O. Deay, professor; B. E. Montgomery, associate professor, and J. V. Osmun, assistant professor.

Research

Professor Troop started research work in entomology soon after he came to Purdue in 1884. After the passage of the Hatch Act in 1887 the Agricultural Experiment Station at Purdue was reorganized in 1888 (7) and Professor Troop was named Horticulturist in the Experiment Station although he did research in entomology as well as horticulture. His principal entomological research was with fruit insects, particularly the codling moth. He described a new species of aphid *(Myzus houghtonensis)*, a pest of gooseberry, in 1906. When the Department of Entomology was organized in 1912, he became its first chief. P. W. Mason was his assistant from 1912 to 1918.

In the same year that Professor Troop came to Purdue (5), F. M. Webster was sent to Purdue as Special Agent of the U. S. Department of Agriculture and Consulting Entomologist of the Purdue Agricultural Experiment Station. Although he was never on the payroll of the University, he was listed as a member of the staff, sometimes as Professor of Economic Entomology and sometimes as Entomologist. Webster was stationed at Lafayette from 1884 to 1891. He did outstanding work while in Indiana on insect pests of the cereal crops. He is the author of the first bulletin of the Purdue Agriculture Station—Bulletin No. 1, The Hessian Fly, Dec. 30, 1884 (1885).

Professor J. J. Davis succeeded Professor Troop as Chief in Entomology in 1920. Since that time there has been a gradual expansion of the research work in entomology until at present there are five full-time and three part-time members of the research staff: These are: J. J. Davis, professor and chief; H. O. Deay, professor; R. T. Everly, assistant professor; G. E. Gould, associate professor; G. E. Marshall, assistant professor; B. E. Montgomery, associate professor; D. L. Schuder, instructor, and M. C. Wilson, instructor.

Research is being done at present on the control of insect pests of corn, greenhouse plants, fruits, legumes, nursery plants, tobacco, trees and shrubs, and vegetables; on flies, termites and soil inhabiting insects; on the reaction of insects to radiant energy and on its possible use as an insect control; on causes of insect abundance; on biological control of insects; on insect pollinators; especially those pollinating legumes, and on plant resistance to insects.

The principal taxonomic studies of the staff have been on the Coleoptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Odonata, Orthoptera and Neuroptera.

Regulatory Work

At present Purdue has no connection with inspection and regulatory work in entomology. However, when the original Indiana San Jose scale and Nursery Inspection Law was passed in 1899, Professor Troop was placed in charge of its enforcement with the title of State Entomologist.

He continued to have charge of this work until 1907 when the State Entomologist's office was moved to Indianapolis.

Extension

The extension work in entomology is under the direction of Professor Davis. Although all of the entomologists who have been connected with Purdue have taken part in extension activities, funds for the employment of an extension entomologist, per se, did not become available until 1936. In March of that year G. E. Lehker joined the staff as its first full-time extension entomologist. The employment of a full-time extension entomologist made it possible to provide Indiana farmers with more complete information about insect pests. In addition to his work with adults, Professor Lehker has been instrumental in developing one of the nation's outstanding 4-H Entomology Club programs. The success of this program in Indiana has been largely responsible for the formation of the National 4-H Entomology Awards Program. This national program provides an incentive for 4-H Club members to participate in the 4-H Club entomology projects in the various states.

In 1922 a Field Station of the Predator and Rodent Control Branch of the Fish and Wildlife Service of the U. S. Department of Interior was established at Purdue. The personnel of this station have been housed with and have cooperated closely with the entomology extension service. Carlyle Carr was first in charge of this station. G. C. Oderkirk has had charge of this station since 1925. He is assisted by W. D. Fitzwater.

Insect Collections

A start toward the development of a permanent insect collection was made early in the history of the University. The Register for 1876-77 (2) states that the zoological museum ". . . embraces specimens of entomology, a few cases being mounted and named, but the greater portion being unmounted." The Fifth Annual Register (3) states that there were 14 cases of specimens of entomology, collected chiefly in the vicinity of Lafayette, and the Scheuch Collection (27 cases) containing 7,000 specimens and over 2,000 species, mostly beetles, from Europe. Unfortunately these early collections have been destroyed and no trace of them remains.

The present Entomological Collection had its beginning with the purchase in 1896 of the T. B. Ashton collection of beetles. This, a named collection largely from New York and Kansas, was the only permanent collection in existence in the department when Professor Davis became Head in 1920. He immediately inaugurated plans for the development of a permanent, well-cared-for collection. At present the Entomology collection contains over 500,000 specimens representing about 15,000 species, 500 of which are represented by type specimens. It includes among others the Davis collection of Aphididae and Scarabaeidae, the Monell collection of Aphididae, the Adams collection of Diptera, a collection of Odonata donated by E. B. Williamson, the Troxler collection of Lepidoptera, the Blatchley collection of Coleoptera, Orthoptera, Hemiptera, and Lepidoptera which were purchased from Dr. Blatchley in 1935, and a collection of Indiana Coccidae donated by Harry Dietz. A majority of the species in the collection are from the United States, but there are several thousand exotic species, most of which are from Europe, South America and Japan.

Staff members in addition to Professor Davis who have made substantial contributions to the Collection are Leland Chandler (Bombidae and other Hymenoptera), H. O. Deay and G. E. Gould (Hemiptera and Homoptera), G. A. Ficht (Noctuidae), B. E. Montgomery (Coleoptera and Hymenoptera), and D. L. Schuder (Coccidae). Many of the students who have majored in the Department have contributed extensively to the collection. Among these are J. M. Amos (Coccidae), C. R. Ash (Tingidae), C. C. Blickenstaff (Thysanoptera), I. C. Brooks (Culicidae), H. E. Brown (Cicadellidae), J. W. Hart (Culicidae), R. R. Heaton (Fulgoridae), J. M. Kingsolver (Trichoptera), V. R. Knapp (Aphididae), D. W. LaHue (Cicadellidae), R. L. Morris (Formicidae), F. E. Skinner (Siphonaptera), A. W. Trippel (Chrysomelidae), and R. F. Wilkey (Collembola).

Conferences Inaugurated at Purdue

Shortly after Professor Davis came to Purdue a meeting of the entomologists of the North Central States was called at his suggestion to discuss their mutual problems (6). This, the first "Annual Meeting of the North Central States Entomologists," was held at Purdue, March 15, 1921. Thirteen entomologists, representing four states (Illinois, Indiana, Missouri and Ohio) and the Bureau of Entomology, attended. The name of this organization was changed to the North Central States Branch of the American Association of Economic Entomologists in 1945 and to the North Central States Branch of the Entomological Society of America in 1953.

In 1937 the Department conducted a five-day conference or short course for the commercial pest control operators. This was the first conference of its kind ever held. It was attended by 68 pest control operators from 14 states. It has been held annually ever since, the 18th conference, which was attended by over 300 PCO's, being held in 1954. In all over 1,200 different persons from 45 states, the District of Columbia, Hawaii, and Canada have attended these conferences. As a result of the success of the Purdue Conference similar conferences have been held at Massachusetts University, Louisiana State University and in California and Canada.

Other conferences initiated and sponsored by the Department are "Use of Aerial Equipment in Agriculture" and "Insect and Rodent Control Conference for Sanitarians." The former of these was first offered March 10-11, 1949, under the title "Short Course for Airplane Sprayers and Dusters" and was sponsored by the School of Agriculture and the Technical Extension Division of Purdue in cooperation with the Indiana Aeronautics Commission and Conservation Department. Since 1952 this conference has been sponsored jointly by Ohio and Indiana and is held in alternate years at Purdue.

The Annual Insect and Rodent Control Conference for Sanitarians was first held in 1946 and is sponsored by the Department of Entomology, the Predator and Rodent Control Branch of the Fish and Wildlife Service of the U. S. Department of Interior, and the Indiana State Board of Health.

Student Organizations

Students at Purdue who were interested in the study of insects formed the Purdue Entomological Society in 1928. The purpose of the society was "to promote and stimulate interest in the science of entomology." In 1931 the name of this society was changed to the Thomas Say Entomological Society of Purdue University. This Society meets each month during the school year and sponsors an annual banquet in the spring which is attended by most of the entomologists in the state.

In 1950 students majoring in the Structural Pest Control Option formed the Alpha Chapter of a national professional pest control fraternity, Pi Chi Omega, on the Purdue campus. The principal objective of this fraternity is "To further the science of pest control."

Entomology Staff Members

The following is a list of those who have been members of the entomology faculty. The letters following their names denote the capacity in which they were employed: A—Administrative, E—Extension, I—Instruction, and R—Research.

P. W. Berg, I, 1946-53; Leland Chandler, I, 1950—; C. R. Cleveland, I, 1921-27; J. J. Davis, A E I R, 1920—; H. O. Deay, I R, 1929—; C. O. Dirks, I, 1925-27; R. T. Everly, R, 1948—; G. A. Ficht, R, 1927-41; G. E. Gould, R, 1931—; G. E. Lehker, E, 1936—; G. E. Marshall, R, 1930—; P. W. Mason, I R, 1912-18; H. E. Milliron, R, 1942; B. E. Montgomery, I R, 1929—; G. B. Newman, R, 1919-20; J. V. Osmun, I, 1948—; W. A. Price, I, 1914-29; H. R. Riley, R, 1927-31; D. L. Schuder, R, 1949—; L. F. Steiner, R, 1927-30; James Troop, A I R, 1884-1941; M. C. Wilson, R, 1947—.

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Regulatory Entomology in Indiana

PAUL T. ULMAN, Department of Conservation

Regulatory Entomology in Indiana covers a period of a little more than a half century. The first law establishing the inspection work was passed in 1899 and was aimed primarily at controlling San Jose scale in orchards and preventing the dissemination of this pest on nursery stock. The enforcement of this law was placed in the hands of James Troop, our first State Entomologist, who at that time was head of the Department of Horticulture and Entomology at Purdue University. The Act of 1899 provided for an appropriation of $1,000 to carry on the work, and certainly this sum was not sufficient, even in that day, to accomplish much in the inspection of nurseries and orchards for San Jose scale.

The Act of 1899 remained in force until 1907 when the legislature passed a more comprehensive law covering the inspection of nurseries in the state and defining the duties of the State Entomologist. The law provided for a separate office of the State Entomologist which shall be in the Statehouse at Indianapolis, consequently the regulatory work in this field was separated from Purdue University.

The Acts of 1907 specified that the State Entomologist shall receive $1,500 per annum and necessary traveling expenses, and a clerk shall be appointed at a salary not exceeding $720 a year. There apparently was no lump sum appropriated covering salaries and general expenses, and one wonders just where the money came from for necessary expenses.

The Acts of 1907 did not provide for apiary inspection, but this situation was remedied in 1909 by additional legislation clarifying the nursery inspection laws and making the State Entomologist the State Inspector of Apiaries. The Acts of 1909 also provided for deputies and specified duties and powers of the State Entomologist in controlling infectious diseases of bees. The Acts of 1909 provided for the sum of $15,000 annually; and for the first time deputies could be put into the field. It is interesting to note that the Indiana State Beekeepers Association was an active organization at this time and it was undoubtedly due to their urging and active support that the Apiary Inspection Law was passed.

The regulatory acts were again amended in 1915, strengthening certain sections and providing for nursery agents and dealers' licenses.

In 1919 the legislature created the Department of Conservation, composed of the following divisions: Geology, Entomology, Forestry, Lands and Waters, and Fish and Game. The State Entomologist Office ceased to be a separate office and became a part of the Conservation Department where the office has remained up to the present time.

The regulatory laws were again amended in 1927, strengthening the powers of the office in relation to introduced agricultural pests: "An act providing for the control and eradication of European corn borer, Japanese beetle, and other destructive insect pests and plant diseases, etc." Introduced pests will be briefly referred to later on.

Professor James Troop has been referred to in the beginning as our first State Entomologist; however, with the creation of a separate office by an act of the legislature, Benjamin W. Douglas was appointed State Entomologist on June 10, 1907, and served until 1911 in that capacity. With the passage of the Act of 1909 deputies were hired and the names of George S. Demuth and Frank N. Wallace appear on the records of the office in 1908-1909. In 1910 the records show that Harry F. Dietz worked apparently part time for the office, and in 1911 Harold Morrison worked for a short period, probably during the summer inspection period, both men later becoming full-time members of this staff.

George S. Demuth should be given special mention as the First Chief Inspector of Apiaries and who later went with the Apiculture Division of the United States Department of Agriculture. George S. Demuth was recognized nationally as one of the outstanding bee experts of his day and was especially recognized for his publications on comb honey production.

Charles F. Baldwin was appointed State Entomologist in 1912 and remained in that capacity until September 30, 1915. It is unfortunate that during this period the names of the members of the office personnel were omitted from the reports.

Frank N. Wallace was appointed State Entomologist in October, 1915, and served in that capacity up to the time that this meeting is being held, October, 1954.

Extensive reports were made each year to the Governor for the first nine reports, well illustrated, and covering many phases of economic entomology. Since the Ninth Annual Report for the years 1915-1916, comparatively brief reports have been issued covering primarily the regulatory activities of the office.

Special mention should be made of the work of Dietz and Morrison, who, under the administration of Frank S. Wallace, reported on the Scale Insects of Indiana Not Heretofore Reported in Indiana, which appears in the Sixth Report, 1912-1913. The Coccidae or Scale Insects of Indiana was then published in April, 1916.

R. E. Snodgrass, who later became associated with the Bureau of Entomology of the U. S. Department of Agriculture, and became known as an outstanding authority in his particular field, made all of the drawings for this publication.

Harold Morrison likewise joined the Bureau of Entomology and is now recognized as an international authority of the Coccidae.

Harry Dietz later became associated with the E. I. du Pont de Nemours & Company and became manager of the Agricultural-Biological Section of the Graselli Chemicals Department, was known throughout the United States for his sound grasp of entomology in all of the ramifications of this broad field. Entomologists throughout the country and his many friends in the Indiana Academy of Science will mourn his untimely passing this fall.

Previous mention was made of introduced pests. The State Entomologist's Office is required by law to take such steps as necessary to deal with new and not widely disseminated insect pests and plant diseases when introduced into the state.

Three major projects have been included in this type of regulatory work, and all of these have involved a cooperative arrangement with the

Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. The first major project was started when the European corn borer was found in Steuben County in 1926. Two additional projects were established in 1934 with the introduction into the state (at Indianapolis) of the Japanese beetle and the Dutch elm disease.

Immediate steps were taken to control both of these, and a program of eradication was started on the Dutch elm disease. Eradication appeared to be a possibility until the smaller European bark beetle, *Scolytus multistriatus*, became widely distributed over Central and Southern Indiana, and this vector of the disease brought about a general infection of our elm tree population. The Dutch elm disease eradication program was discontinued in 1947.

The Japanese beetle control program has been successful in eliminating many of the isolated infestations by using soil insecticide treatments, but it is undoubtedly just a question of time until we all will have to learn to live with this introduced insect. It is felt, however, that the regulatory program has retarded a serious agriculture pest up to the present time, and with the introduction of biological controls and new insecticides, it may not be as serious a threat to agriculture as when it was first reported in the state.

It should not be necessary to duplicate the records already assembled by John J. Davis in his Presidential Address before the Indiana Academy of Science in 1931 and so this report will merely attempt to bring the regulatory personnel up to date.

The Apiary Inspection work has been supervised by James E. Starkey, 1931 to 1948; Gerald Hodson, 1948-1949; Gilbert Perigo, 1949 to date.

The present staff of the Entomologist's Office includes the following: Frank N. Wallace, State Entomologist, 1915 to date; Paul T. Ulman, 1926 to date; John J. Favinger, 1942 to date; James A. Clark, 1941 to date, and G. Earl Huff, 1952 to date. The names of Albert W. Trippel and Henry W. Gilbert should be added to this list as they are former members of the staff, Albert Trippel from 1936 to 1951 and Henry Gilbert from 1932 to 1935.

Federal Entomology in Indiana[1]

PHILIP LUGINBILL, SR.

Entomology had its inception in Indiana by the Federal Government in 1884 when F. M. Webster was appointed as special agent by the Bureau of Entomology of the U. S. Department of Agriculture, and stationed at Purdue University where he also acted as consulting entomologist of the Agricultural Experiment Station. While there, he made careful observations on corn insects and how they may be controlled. He was also interested in the Hessian fly, and wrote the first publication of the Purdue Agricultural Experiment Station on this insect. After spending several years here he resigned his position to become State Entomologist of Ohio, but soon thereafter he rejoined the Bureau of Entomology as leader of the Division of Cereal and Forage Insects with headquarters in Washington, D. C.

Webster's interest in Entomology in Indiana continued, and resulted in the establishment of the first federal field laboratory in Indiana at Richmond in 1905 with W. J. Phillips in charge. In 1909, this laboratory was moved to the Purdue Experiment Station at West Lafayette, Ind. In 1913, a separate building nearby was leased to accommodate the enlargement of the work. Phillips remained in charge until 1913, when he was transferred to Charlottesville, Va.

He was succeeded by J. J. Davis who continued in charge until 1919 when he accepted the position of taking charge of the Japanese beetle work at Riverton, N. J. From 1919 to 1925 this laboratory was in charge of W. H. Larrimer. W. B. Cartwright was temporarily in charge from August, 1925, to August, 1926. During the latter part of this period C. M. Packard was transferred to this station to take charge of its operations which consisted of studies of the Hessian fly and other cereal and forage insects. Packard was called to Washington in 1937 to take charge of the Division of Cereal and Forage Insects, and Philip Luginbill was placed in charge, which position he held until he retired in 1950. He was succeeded in charge by W. B. Cartwright, who is in charge at the present time. It should be mentioned that since 1932 the Laboratory has been situated in the Post Office Building at Lafayette, Ind.

During the period, 1905 to date, many workers have been connected with this station. W. J. Phillips, 1905-1913, in charge; T. H. Parks, 1909; Philip Luginbill, 1910-12, 1933-1950; J. J. Davis, 1911-1919 (in charge 1913-1919); C. W. Creel, 1911-1912; Henry Fox, 1912-1913; A. F. Satterthwait, 1913-1916; R. J. Kewley, 1914-1916; D. G. Tower, 1915-1916; F. A. Fenton, 1915-1916; W. H. Larrimer, 1916-1925 excepting during army service from 1917 to 1919 (in charge 1919-1925; J. M. Aldrich, 1917-1918; W. O. Hollister, 1918-1919; R. J. Fiske, 1919-1920; A. L. Ford, 1919-1920; C. F. Turner, 1919; F. L. Simanton, 1919-1920; R. A. Blanchard,

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[1] The author wishes to thank the following for providing helpful information: J. J. Davis, V. E. Fahey, D. W. Hamilton, B. A. Porter, and A. M. Vance.

1920; W. B. Cartwright, 1920-1926, 1938 to date (in charge 1925-1926, 1950 to date); S. Blum, 1920; H. R. Painter, 1920-1950; G. B. Pearson, 1920-1922; W. B. Noble, 1922-1938; Curtis Benton, 1924-1949; C. M. Packard, 1926-1937 (in charge 1926-1937); George G. Ainslie, 1929-1930; E. V. Walter, 1936 to date; D. W. LaHue, 1935-1943 (left for military service 1943); Robert Gallun, 1952 to date.

During this long period of about 50 years many important studies of cereal and forage insects have been made. Much of these results have been published as articles in journals and bulletins. From 1909 to 1913, under the direction of W. J. Phillips, the important studies included the wheat jointworm and aphids as well as general cereal and forage insect feeders. From 1911 to 1919, under the direction of J. J. Davis, emphasis was given to the white grub problem, although progress was also made on studies of several species of aphids and the Hessian fly.

From 1919 to 1925, under W. H. Larrimer, the Hessian fly was the major project, although attention was also given to grasshoppers and other clover and grass insects; under the direction of C. M. Packard, the Hessian fly continued as the major project, but during the latter part of his reign the chinch bug was given much attention. Under the direction of Philip Luginbill the chinch bug received a large amount of attention and white grub studies were continued. At the present time, Hessian fly studies on resistant wheats are in progress with W. B. Cartwright as Project Leader, assisted by Robert Gallun, and corn earworm studies under the direction of E. V. Walter.

For several years the Bureau of Entomology maintained a laboratory at Plymouth, Ind., for the investigation of truck crop insects. H. K. Larrimore was first in charge of this station. M. R. Smith was connected with this laboratory in 1917 and 1918, being in charge in 1918. During the last year of the existence of this station Smith was assisted by J. M. Craig. Incidental to the economic studies, Smith made a study of the syrphid fly fauna of that area, and published a list of the species encountered at Plymouth.

There was a demand for federal assistance in studying deciduous fruit insects in the central west, and as a consequence, A. L. Quaintance, in charge of deciduous fruit insect investigations of the U. S. Bureau of Entomology at Washington, established a laboratory at Vincennes, Ind., in 1923 with B. A. Porter in charge. This was a cooperative laboratory, as the Purdue Experiment Station and the growers in the vicinity contributed funds to aid in the work. Investigations which had been carried on by Purdue since 1921 were turned over to the federal workers. The main projects the first few years of the laboratory were studies of lubricating-oil sprays for the control of the San Jose scale, the cause and control of peach catfacing, and the use of paradichlorobenzene for peach borer control in Southern Indiana. This last chemical proved successful in controlling the borer. B. E. Montgomery was employed as a summer assistant in 1924. Much of the work outlined for 1923 was continued. The tarnished plant bug was shown to be one of the causes of catfacing. J. E. Bussart served as a summer assistant in 1925, and late in the fall R. F. Sazama was transferred from Maine to assist in the work at Vincennes.

In 1926 and 1927 a crisis developed in the problem of arsenical spray residues on apples as a result of the use of lead arsenate for codling moth control. Numerous arsenicals other than lead arsenate were tested, and a limited number of non-arsenicals.

In 1928 B. A. Porter was transferred to the Washington office for the study of deciduous fruit insects. In 1929, W. P. Yetter was appointed to the Vincennes laboratory and assigned to work on the Oriental fruit moth. He tested numerous insecticides and bait materials against this pest, which had by that time become widespread and destructive throughout the area. In 1930 F. H. Lathrop was transferred from Maine, and was placed in charge of the general work of the laboratory. Yetter continued in charge of the Oriental fruit moth work.

An appropriation of $150,000 was obtained to carry on large-scale experiments to control the Oriental fruit moth with baits. In 1932 the large-scale tests were discontinued due to the lightness of infestation and reduction of funds. Mr. Yetter was transferred to Georgia, and Lathrop was transferred to Whittier, Calif., leaving R. F. Sazama temporarily in charge. But in 1934, L. F. Steiner was transferred from Georgia and placed in charge until 1949 when he was sent to Honolulu, T. H., to study the Oriental fruit fly.

Entomologists on the staff during the time Steiner was in charge were R. F. Sazama (resigned in 1937); A. J. Ackerman, 1934 through 1936 (died); S. A. Summerland, 1936 through 1953 (retired); B. E. Hodgson, Jr., 1937 through 1940, and H. J. McAlister, 1946 through 1952 (transferred). Sub-professional employees on the staff were C. H. Arnold, 1941 through 1943; and K. W. Lamansky, 1946 to date.

During the period when Steiner was in charge of the laboratory, numerous college students worked as summer assistants. Among the well-known in Entomology are J. M. Amos, now with the Virginia Agricultural Experiment Station, and C. C. Alexander, now with the Geigy Agricultural Chemicals.

Codling moth damage to apples was severe in the 1930's. Lead arsenate was not maintaining control. Besides the laboratory at Vincennes, a sub-laboratory was maintained at Orleans, Ind., in 1934 and 1935 with D. W. Hamilton in charge, and S. A. Summerland as an assistant. The effect of light traps and bait traps were evaluated, and information relative to the habits of the codling moth was obtained. During the period 1934 to 1943 the number of materials screened and tested at Vincennes for codling moth control was very large. The first DDT ever applied to apple trees was at Vincennes in 1943. The control obtained was so good it was astonishing. Large-scale tests with DDT followed, and results obtained were almost perfect. However, other problems developed from the use of DDT. The European red mite population was increasing, and the lady beetle population was decreasing.

In 1949, D. W. Hamilton returned from New York to take charge of the laboratory, and is in charge at the present time, being assisted by K. W. Lamansky. A large number of publications have emanated from this laboratory during the period of its operation.

In June, 1934, the Division of Insecticide Investigations of the Bureau of Chemistry and Soils established a chemical laboratory at Vincennes to cooperate with the Fruit Insect laboratory. Jack E. Fahey was transferred from Wenatchee, Wash., to take charge of this work, and he has been in charge of the chemical investigations at Vincennes since that time. H. W. Rusk was transferred to Vincennes to serve as assistant to Mr. Fahey and has served in that capacity, except for a two-year period during 1943 and 1944, since that time.

In September of 1935 the Insecticide Division of the Bureau of Chemistry and Soils was transferred to the then Bureau of Entomology. It is now the Pesticide Chemicals Research Section of the Entomology Branch, Agricultural Research Service.

From 1934 through 1943 the Pesticide Chemicals Research Section contributed to the study of control of fruit insects by study of the magnitude, distribution, weathering, and removal of insecticide residues, as well as the study of insecticide formulations.

Since 1943 these studies have been continued with the new synthetic organic insecticides. In addition, the rapidly developing use of these insecticides on field crops has presented the problem of residue studies on these crops. The Pesticide Chemicals Research Section laboratory at Vincennes now furnishes chemical residue studies for most of the Research stations of the Entomology Branch within the North Central States area.

European corn borer research at West Lafayette was started in March, 1942, when L. H. Patch, Morris Schlosberg and Ray T. Everly were transferred from the main federal corn borer laboratory at Toledo, Ohio, to West Lafayette, Ind. A. M. Vance joined the staff in August of the same year to take charge of the station. However, in 1949 Vance was transferred to the main office in Washington and appointed as assistant chief of the Division of Cereal and Forage Insects. Messrs. Patch, Schlosberg and H. R. Painter, who earlier was transferred from the general Cereal and Forage Insect office to the corn borer project in 1943, were all transferred to Ankeny, Iowa, in 1950 to start research on the corn borer in cooperation with the Iowa State College of Agriculture. Ray T. Everly was transferred from the West Lafayette laboratory in 1946 to Columbus, Ohio, to work on legume insects. E. J. Udine and L. L. Stitt were members of the Corn Borer Laboratory from 1943 to 1945.

The main project at the corn borer station was the testing of dent, sweet and popcorns to find resistant germ plasm which could be used by the corn breeders in the corn improvement program. Patch worked on dent corn, Schlosberg on sweet corn and popcorn. Both cooperated with corn breeders at the Purdue Agricultural Experiment Station. Painter was responsible for the production of eggs for manually infesting the corn plots, and made photographs. Everly spent considerable time in evaluating corn strains for their resistance to oviposition by moths of the corn borer. This station operated as a sub-station of the Toledo, Ohio, station. The corn borer workers received most encouraging and helpful cooperation from the Entomology Department at Purdue as well as from the entire Purdue Experiment Station.

Entomology at Indiana Universities, Colleges, and Other Institutitos Since 1854[1]

Frank N. Young, Indiana University

Indiana has produced a surprisingly large number of outstanding entomologists during the period since 1854. Whether we attribute this to pure chance, weather, or merely a statistical excrudescence produced by Hoosier pride, the apparent fact remains. The contributions of many of these men have already been acknowledged, but there are others worthy of note. Some were professionals; some we would call "rank amateurs." Some earned their living through their entomological work; others collected and studied insects purely for the fun of it. Regardless of their standing in relation to the professional field, however, no history of entomology in Indiana would be complete without mention of several whose names are known throughout the world.

The Early Collectors and Naturalists

During the period from 1854 to the early 1900's, most of the students of insects outside the applied phases were collectors who did little besides accumulate specimens. These collections were sometimes studied by others or, more frequently, were merely destroyed upon the death of the individual. The importance of these men is mainly through the influence which they exerted on those who came later.

In this group we must mention W. P. Shannon (1847-1897), who collected insects while living at Evansville and Greensburg, and George C. Hubbard, who furnished Blatchley with butterfly records from around Madison. Both presented reports on insects before the Indiana Academy in the 1880's; but the papers were never published, and the collections on which they were based are now apparently lost.

Among the most important collections made during this period was that of George Mitten (1826-1906), who collected Lepidoptera and other insects while he lived at Goodland. Part of his fine collection is now at Purdue University. Samuel G. Evans (1839-1929) lived at Evansville from shortly after the Civil War until his death. He was particularly interested in the Lepidoptera, and is said to have prepared one of the finest collections of this order ever assembled in the state. Unfortunately, he never published lists or records, and most of his collection was lost through carelessness and neglect. R. J. Weith (1847-1902) lived in Elkhart for many years, and worked on Hymenoptera and Odonata. He is said to have made several important discoveries and many new records; but again, unfortunately, he published no papers, and his collection was scattered after his death.

Other collectors included Dr. T. G. M. Levette of Indianapolis, who made an extensive collection of Coleoptera, part of which was sold to T. L. Casey and is now in the U. S. National Museum. Dr. F. Stein, who also practiced medicine in Indianapolis, made another excellent collection of beetles, some remnants of which were turned over to W. S. Blatchley.

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[1] Contribution No. 575 from the Zoological Laboratories of Indiana University.

The entomological work of Blatchley (of whom more later) also began in the 1880's and continued until his death in 1940. One of his important contributions was the accumulation and compilation of records of insects in many groups. His extensive collections, now at Purdue University, stand as a monument to his many years of industrious efforts.

J. J. Davis has summarized much of our information concerning these early workers, and reference should be made to his paper (*Proc. Indiana Acad.*, 41: 43-70, 1932) for further pertinent details.

Many entomologists collected or studied insects in Indiana during the late 1800's and early part of the present century. Davis *(op. cit.)* mentions among others the following: Melville T. Cook (insect galls); O. S. Roberts (Lepidoptera); C. F. Adams (Diptera); J. Speed Rogers (Diptera); Emil Beer (Lepidoptera); William J. Gerhard (several groups of insects); A. B. Wolcott (Coleoptera); Emil Liljeblad (Coleoptera), and Alex K. Wyatt (Lepidoptera). Indiana insects collected by several of these workers are in museums throughout the country, especially the Chicago Natural History Museum and the University of Michigan Museum of Zoology.

Countless entomologists must have found Indiana a pleasant and profitable collecting place, but their visits are mostly forgotten except for the records and descriptions in scattered monographs and papers. A notable exception is the visit of the French entomologist, R. G. Jeannel, who came to study cave insects in the 1920's. His visit is remembered largely because he wore a beret, and insisted on crawling into the most unlikely holes in the ground.

Besides collecting in Indiana, several Hoosier entomologists behaved as if they had the six legs and the wings of their pets. W. S. Blatchley accompanied an expedition to Orizaba in Mexico in 1891 and published several papers on his collections. He later traveled extensively in South America. E. B. Williamson traveled widely in Central and South America in pursuit of dragonflies, many of which he later described as new. Fernandus Payne collected many specimens of Hemiptera and Homoptera for his cytological work in the South and West. A. C. Kinsey and his students explored the United States, Mexico, and as far south as Guatemala for gall wasps and other insects. These collectors and many others have added greatly to the collections of American museums and to the general advancement of entomology.

Entomology at Indiana University

Entomology at Indiana University is not considered a separate discipline, and no distinction is made between it and other fields of general zoology. There has been, however, from the time of David Starr Jordan, a considerable amount of emphasis upon the study of insects; and a considerable amount of research in taxonomy, cytology, physiology, genetics, and ecology of insects has been carried on.

The first course in Entomology as such was taught in 1886 by the distinguished geologist James C. Branner (1850-1922). We know little of the success of this course, except that three of Branner's students became outstanding entomologists: W. S. Blatchley, Jerome McNeill (1857-1928), and Charles Bollman (1868?-1889). McNeill taught at Florida State College for many years, and was a recognized authority on Orthoptera. Bollman became the American authority on the millipeds, but died at the early age of 21 of malaria at Waycross, Georgia.

According to the catalogue for the year 1886-1887, two courses in entomology were offered: "VII. *Entomology.* Lectures on general entomology; discussion of the orders, families or species of local and economic importance; field and laboratory work. *Third term, daily.*," and "VIII. *Advanced Entomology.* Field and laboratory work; methods of investigation; anatomy, habits and life history of insects; methods of capturing, handling, mounting, labeling, arranging and preserving insects. *Year's course, daily.*" In the same catalogue, the *Entomological Laboratory* is described as being on the second floor of Owen Hall. Microscopes and appliances were available as well as a collection of specimens and reference works.

In another section of the 1886-1887 catalogue the University Museums are described. Besides the geological and other collections, a separate section was apparently devoted to entomology, described as follows:

"Entomology

"Although the work in this department began only recently, the collections are already extensive and are growing at a remarkable rate. It numbers, at present, about six thousand specimens, representing about a thousand species. The collection of myriapods is one of the largest in the country, representing not only the myriapods of this state, but also of the whole United States.

"The collection of Prof. Branner, made in Brazil, and that of Mr. C. H. Bollman, made in the vicinity of Bloomington, have been deposited with the material belonging to the Museum.

"Through Prof. C. V. Riley, United States Etomologist [sic!], this department has also received a collection of insects selected for the purpose of illustrating lectures upon the various orders and families.

"Prof. J. H. Comstock, of Cornell University, has also contributed a valuable series for similar purposes. A considerable series of beetles and other insects has also been presented by Prof. O. S. Westcott, of Chicago.

"All the insects, whether mounted or in alcohol, are so arranged that they are readily available for either laboratory or classroom work or for exhibition."

In the intervening years, this collection has both diminished and grown. Many specimens collected by W. S. Blatchley and others are still included, but time and use have destroyed many of the older specimens. The Bollman collection of myriapods, including some types of species described by him, was unfortunately lost due to evaporation of alcohol and was probably abandoned at the time the zoology department moved into the present building. The collection remaining was largely rehoused and enlarged by A. C. Kinsey after 1920, and is at present being renovated and partly transferred into museum drawers by the writer.

After the brave beginning in 1886, entomology as such languished for nearly 35 years, until revived in 1921 by A. C. Kinsey. During the intervening years, the study of insects was included as an important part of the general course, but was not considered a separate subject. From 1910 until 1916, the third semester of the beginning course was called "Insects and Birds," and was taught first by Fernandus Payne and later by Will Scott.

There was considerably more entomological activity during this period at the Biological Station than on the Bloomington campus. W. S. Blatchley lectured on insects at the Station on Lake Wawasee in 1895. The Station was later moved to Lake Winona, and among the outstanding lecturers was James G. Needham. During the period from 1900 until about 1910, Thomas J. Headlee, Leonard Haseman, Clarence H. Kennedy and Norman E. McIndoo were all at various times assistants or instructors at the Station.

Although little formal training in entomology was available between 1886 and 1921, the inspiration of Carl H. Eigenmann, Will Scott, and others in zoology seems to have been enough to produce, to encourage, or at least to start on their way a number of outstanding entomologists: Leonard Haseman (State Entomologist of Missouri); Thomas J. Headlee (State Entomologist of New Jersey); Clarence H. Kennedy (Professor of Entomology at Ohio State University); Waldo L. McAtee (USDA and U. S. Fish and Wildlife Service); Norman E. McIndoo (USDA); and George D. Shafer (Professor of Entomology at Stanford University). Of these McAtee apparently received no further formal training in entomology, but made notable contributions through his studies on insects as the food of birds and other animals. The others took their doctorates at Cornell University under J. H. Comstock, except McIndoo who completed his work at the University of Pennsylvania.

From the spring of 1921 until 1944, A. C. Kinsey offered several courses in general, medical, and economic entomology each year. The course in Taxonomy (1922-1937) was also largely concerned with insects, and finally evolved into the course in Evolution (1936-1937). Lamont C. Cole taught entomology and ecology from 1946 until 1948. The present writer took over the work in entomology in 1949, and the present course in Ecology also deals extensively with insects.

Students who have received their doctorates at Indiana in the field of entomology are: Robert E. Bugbee (1936); Osmond P. Breland (1936); Merle E. Jacobs (1953); Herman T. Spieth (1931), and Ralph Voris (1928). Voris produced a considerable amount of excellent research on the comparative anatomy, biology, and taxonomy of the Staphylinid beetles before his death in 1939.

A considerable amount of research is carried on at Indiana on several aspects of biology in which insects serve as experimental material.

Dean Fernandus Payne (1881—) has made outstanding contributions to cytology through his studies on Hemiptera and Orthoptera. He was one of the first workers to demonstrate cytological differences in insects where taxonomists had not recognized morphological differences. In 1907, while a graduate student at Columbia University, he established one of the first cultures of *Drosophila melanogaster*, and performed a series of genetic experiments on this fly both at Columbia and later in Indiana.

H. J. Muller joined the staff in 1945; and he, his associates, and students have continued research on the genetics of *Drosophila.*

W. E. Ricker carried on studies on the Plecoptera in connection with his limnological research while he was director of the Indiana Lake and Stream Survey from 1939 to 1950. Shelby Gerking has also studied the Gyrinidae and other aquatic insects in connection with limnological activities.

Instruction and Research at Other Institutions

A number of courses in entomology has been offered at state institutions other than Purdue and Indiana.

Ball State Teachers College—Robert H. Cooper has taught a course in general entomology since 1936, and has also conducted research and published several papers on insect anatomy and biology, particularly of the Orthoptera. Donald Miller also taught entomology there. The College maintains a collection of insects representing the principal orders and families.

Butler University—A general entomology course was formerly offered by H. G. Nester, and the University maintains a considerable collection of various orders and families of insects. The collection includes South American butterflies, representative Cynipidae from the Kinsey collection, and Odonata from the Williamson collection. Dr. Nester has been especially interested in the pseudoscorpions. Nathan E. Pearson has also made notable contributions to cytology through his studies of insects.

DePauw University—Walter N. Hess taught a course in entomology every other year until about 1928. He also conducted research on the chordotonal organs of beetles, and the morphology and biology of fireflies.

Earlham College—William Burbank has offered a general course in entomology every other year. The College maintains a collection largely of Wayne County insects.

Franklin College—Insect study has been provided from time to time, but no formal course in entomology seems to have been offered.

Goshen College—No courses in entomology have apparently been offered in recent years. Merle E. Jacobs was a member of the staff in 1953-54 and continued his studies of dragonfly behavior.

Indiana State Teachers College—C. W. Allyn has offered a general course in entomology which often enrolls seventy to eighty students. No research is apparently in progress at present.

Indiana Central College—William P. Morgan has done a considerable amount of work on insect cytology and has also worked on the Dermaptera of Indiana. The College maintains a small insect collection.

Manchester College—No special courses in entomology seem to have been offered, but Professor Emeritus Edward Kinter has maintained an interest in insects and spiders.

Notre Dame University—No special courses in entomology seem to have been offered. Some research in general zoology has used insects as experimental material.

Valparaiso University—Frank R. Elliott previously offered a course in general entomology during the summer session. He has also worked for many years on the spiders of Indiana. Carl H. Krekeler at present teaches the entomology during the summers, and is continuing his research on cave beetles.

Vincennes University—A general course in entomology has been offered since 1951 by Charles L. Haggard.

Wabash College--Donaldson Bodine (1866-1914) taught at Wabash College for many years and his interest in entomology probably caused him to place considerable emphasis on insects in his course.

Other Distinguished Hoosier Entomologists

Indiana is the birthplace of a considerable number of nationally known entomologists, who, however, received most of their training and achieved prominence elsewhere. Outstanding in this group are: Marshall A. Barber (pioneer in the use of Paris green as a larvicide against anopheline mosquitoes); Andrew N. Caudell (authority on Orthoptera); Russell Myles Decoursey (Professor at the University of Connecticut); Edward O. Essig (distinguished Professor of Entomology at the University of California); Maurice T. James (authority on Diptera); Oscar William Oestlund (1857-1948, Professor at the University of Minnesota); J. Speed Rogers (Director of the Museum of Zoology of the University of Michigan, and authority on Diptera); Robert L. Webster (Professor of Entomology and head of the Department of Zoology at the State College of Washington).

In this group we should also include Dr. Herbert C. Clark, born in Economy, Indiana, in 1877. He served many years as director of the Gorgas Memorial Laboratory in Panama, and is a world authority on malariology.

Many other entomologists are at present working in the state, have been employed in the past, or obtained all or part of their training here. It is impossible to mention them all, and it is hoped that none will take offense if their names are omitted. Those which come immediately to mind are: Griffin J. Baker (Standard Oil Company of Indiana); John P. Barrett (Armour and Company, Chicago—has collected Diptera in Indiana for several years); Edward Junior Campau (Standard Oil Company of Indiana); David Tracy Jones (Miami (O.) University—insect physiology); John Gilbert Shaw (USDA); Lee Campbell Truman (Arab Pest Control Company and Federal Chemical Company).

The Outstanding Hoosier Entomologists of the 20th Century

Indiana has long been recognized as a center of entomological activity and research. This wide recognition has come about, in my opinion, largely through the contributions of four outstanding men. I think that we can call them all "Hoosiers" although only one of the four was actually born in Indiana. Few states can boast a more distinguished group of internationally known entomologists.

Few who have had even the most casual contact with insects will fail to recognize the name of Willis Stanley Blatchley (1859-1940). His boundless energy, keenly analytical mind, and wide interests have left an indelible mark not only upon Indiana, but upon the whole science. If he had done nothing else, we would still have to consider him the foremost Hoosier entomologist for his great work "On the Coleoptera Known to Occur in Indiana." Add to this his works on "The Orthoptera of Northeastern America," "The Heteroptera or True Bugs of Eastern North America . . . ," and "The Rhynchophora or Weevils of Northeastern America" (with C. W. Leng), as well as his many shorter papers, and we must concede his place among the great American entomologists.

Blatchley was born in North Madison, Connecticut, in 1859 and died in Indianapolis in 1940. His parents brought him in 1860 to Hendricks County, Indiana, and from that day until his death there was never a more devoted Hoosier. He received the A.B. from Indiana University in 1887, the A.M. in 1891 and was awarded an honorary LL.D. in 1921. He taught in the Terre Haute High School and briefly at Indiana University, but his main contributions were made during his long tenure as State Geologist (1894-1911). His adopted state honored him by re-electing him four times as State Geologist, and his final defeat by a small plurality was probably influenced by differences with the governor over the publication of the work on Coleoptera. In 1912 he was suggested by several newspapers as a suitable Republican candidate for governor.

Blatchley's contributions to entomology, aside from the manifest usefulness of his various manuals, was largely in the field of taxonomy. He described over 350 new species of Coleoptera, 66 Hemiptera, 29 Orthoptera, and numerous new genera and subgenera. In his later life he lived during part of the year in Florida, and his contributions to the knowledge of the fauna of that state were extensive. He was never, however, the strict entomologist. He was the general naturalist and homespun philosopher of nature. An original poem written of him as the dedication of a book by his friend James Whitcomb Riley makes a fitting epitaph:

"He owns the bird-songs of the hills—
The laughter of the April rills,
And his are all the diamonds set
In Morning's dewy coronet."

The second of our four, Edward Bruce Williamson (1877-1933) was born at Marion, Indiana, in 1877, and spent most of his adult life as president of the Wells County Bank in Bluffton. Despite his vocation, however, there has seldom been a more enthusiastic student of insects, and he spent long hours in his laboratory at home working on the classification and biology of his beloved dragonflies. His main contributions to entomology were in the field of taxonomy. He described numerous new species and genera of Odonata, and was the author of more than 100 papers on the group, including many on Indiana forms. In 1929 he gave his large collection of dragonflies to the University of Michigan Museum of Zoology, where it forms the nucleus of a very extensive collection of the group.

Williamson was not only a keen entomologist, but a man of wide interests. He studied birds, collected birds' eggs, and raised irises both as a business and a hobby. Many fellow workers were inspired and sustained by his friendship and interest. No one who knew him has anything but the most complimentary things to say of his character and industry. His death at the early age of 56 was a distinct loss to Indiana and to entomology.

The third, Alfred Charles Kinsey (1894—) occupies a unique position in having achieved prominence in two fields of biology—entomology and human behavior. He was born in Hoboken, N. J., and came to Indiana University in 1920 as Assistant Professor of Zoology. He is at present a Professor of Zoology at Indiana, and director of the Institute for Sex Research. He received the B.S. degree from Bowdoin College in 1916, and the Sc.D. from Harvard in 1920. At the latter institution he worked under William Morton Wheeler and Charles T. Brues.

Kinsey's entomological work represents a distinct departure from that of his predecessors, and he did much to establish the modern techniques of research in taxonomy. His insistence upon massive series, wide geographical coverage, and detailed analysis of every biological aspect of an organism were unique at the time, but have become almost standard practices in present-day taxonomic studies. It is interesting that Kinsey's success in studying human behavior has resulted in part from the application of similar methods. He still asserts that he is primarily a taxonomist dealing with a primarily taxonomic problem.

Kinsey's most important entomological works are: "The Gall Wasps Genus Cynips, A Study in the Origin of Species" (1920), and "The Origin of Higher Categories in Cynips" (1936). He is also the author of numerous short papers, and has described many species, genera, and subgenera of Hymenoptera. One of his many important books outside the field of entomology is "An Introduction to Biology," (1926) which served as an important high school text for many years, and was used widely throughout the United States. Although his recent work is outside the generally accepted field of entomology, he still maintains his extensive collection of Hymenoptera, representing over 5,000,000 galls and 3,500,000 gall insects.

Finally, since it is customary for entomologists to confer titles upon their fellows, I think it only fitting that we confer that of Dean of Indiana Entomologists. I propose that we award it to the fourth of Indiana's internationally famous entomologists, whose contributions have been acknowledged repeatedly elsewhere in this symposium, John June Davis (1885—). It has been largely through his efforts and activities that professional entomology has attained such a high level in Indiana. He has been friend, guide, and enthusiastic sponsor of every phase of our science.

The Field of Entomology
Its Past, Its Present, Its Future

J. J. DAVIS, Purdue University

It is interesting to look at the past and speculate on the future. As I have said on other occasions, we study the past to understand the present and prepare for the future.

From Doctor Montgomery's paper you have learned that entomology and insect problems are as old as history. From Curtis Wilson you have found that insects were recognized as a problem from the earliest history of Indiana. However, Entomology, at least economic or applied entomology, is a comparatively new science. To be sure, we are celebrating the 100th anniversary of Professional Entomology and yet the science of insect control is perhaps only 75 or 80 years old. It seems to me we can consider the development and use of Paris green in the late 70's as the beginning of scientific insect control.

During the sixty years following the discovery of Paris green there was a gradual development in insecticides, each new development being brought about because of a special need. Therefore, arsenate of lead was developed because of the need of a safe stomach poison on a variety of plants to control the gypsy moth, calcium arsenate as a dust for use on cotton, oil sprays to replace lime-sulphur for scale insects, and so on. During this period greater and greater emphasis was given to good practices as a control and this of course applied primarily to field crops which were extensively grown and whose value did not warrant the use of expensive insecticides. It should be noted here, that in spite of new insecticide developments during the past 12 or 15 years, good practices such as good agronomic practices, sanitation and the like, are still more important to insect prevention and control than anything else. And may I remind you these are preventive practices, operating before damage is done by providing conditions unfavorable for insect development.

Then came World War II and with it a realization that our armed forces would be in areas where insect-borne diseases would be a factor. It is to the credit of the Swiss scientists that the first effective chlorinated hydrocarbon, DDT, was discovered as an effective insecticide and in particular effective against insect carriers of disease, such as fleas, flies, mosquitoes, and body lice. We have ample evidence that the discovery of DDT and aerosol bombs, and their use in the Southwest Pacific were responsible for shortening the war against Japan perhaps by many years. To be sure, the atom bomb ended the strife but the insecticides were a major factor in setting up the final stroke.

Since the advent of DDT dozens of other organic chlorinated hydrocarbons have been developed and these have been followed by the phosphate compounds. The end is not in sight.

As I intimated a minute ago, entomologists are losing sight of the good agronomic and sanitation practices which are so essential if we expect full use of insecticides, whatever they may be.

There is no question that we have come into an era of chemical control. The present chemicals can be used in almost unbelievably small quantities resulting in a low cost per acre. Likewise low pressure type sprayers and the airplanes have made it possible to use insecticides profitably on such extensively grown crops as corn, legumes, and others. The development of insect resistance to the new chlorinated hydrocarbons is a factor we had not anticipated in the beginning.

As for the future, perhaps my guess is as good as yours. New chemicals are certain to be developed and we should expect them to be as good or better than those of the present. Greater emphasis will be given to safer insecticides and safer methods of application. Farmers will provide themselves with low-pressure sprayers as a part of their regular essential equipment. The airplane and perhaps especially the helicopter, will become major factors in insect control, because there are innumerable situations where ground equipment will be impractical. The telephone lends itself to obtaining immediate information which is so essential in prompt and effective control of insect pests. The telephone is being utilized more than ever before in place of mail correspondence. Dealers are maintaining adequate stocks of insecticides being recommended so that materials are increasingly more available. County agents, who are such important contact agents, are keeping abreast of developments and are in a position to make recommendations in many cases. The successful long-range predictions by meteorologists and the likelihood of even longer predictions, provides an aid of great importance in predicting insect troubles. And finally, there is an increasing number of professional operators to do service work. All of these factors are certain to make insect control more effective in years to come and this, in turn, will be a major factor in increased production of food and at a lower cost.

GEOLOGY AND GEOGRAPHY

Chairman: BENJAMIN MOULTON, Butler University

WILLIAM J. WAYNE, Indiana University, was elected chairman for 1955

ABSTRACTS

Origin and Development of Caverns in the Beech Creek Limestone in Indiana. PRESTON MCGRAIN[1] and ORVILLE L. BANDY.[2]—Caverns developed in the Beech Creek limestone of Indiana strikingly reflect the physical characteristics of this formation. The main passages are joint controlled; they are narrow, tall, and turn frequently at abrupt angles. Side passages at intersecting right angles are common.

These caverns are in youthful stage of development. Streams course the main arteries at all seasons. Decorative dripstone and flowstone formations are rare. Rockfalls and collapse features are also rare except where the surface cover is thin.

The outcrop of the Beech Creek limestone, from the Ohio River northward for more than 90 miles, forms the most important spring-bearing horizon of any of the Chester formations. Locally openings have been enlarged until they reach cavernous proportions. Four caves, located in Greene, Martin, and Orange Counties, were mapped and studied in detail.

The Cypress formation, which overlies the Beech Creek limestone, is characteristically a thick, massive, jointed, and porous sandstone which collects precipitation, runoff, and subsurface waters. In the highly dissected Crawford Upland physiographic region, where major drainage lines have cut through these Chester formations, waters move freely in the Cypress sandstone until they reach the massive Beech Creek limestone, where downward percolating waters are concentrated in streams along the pronounced joint planes and bedding planes. The upper strata of the subjacent Elwren are characteristically gray shale or siltstone. Here the downward movement of water is obstructed, and it then moves laterally to the surface. The origin and development of Bear, Ray's, and Tow Caves can be explained in this manner. Enlargement is still continuing. Modification due to collapse and diversion of surface waters through sinkholes is minor.

The initial openings in the American Bottoms cavern system were formed in the same manner. Enlargement has taken place, and is taking place, as a result of the invasion of waters from Bridge Creek.

Three Dimension Maps in Color. BERNARD H. SCHOCKEL, Valparaiso University.—There is need for progress in the production of three-dimension, bona fide maps in color.

It has been established that they cannot be based successfully upon arrangement of color hues, or upon arrangement of color vividness.

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[1] Kentucky Geological Survey.

[2] University of Southern California.

Quantitative precision has long been achieved by the use of bands of color hues to portray the contour spaces. Now, in addition, the third dimension can be achieved in such maps by the use of high lights and shadows, and by use of direction of stroke. Thereby all slopes are portrayed in three dimensions, i.e., by the use of color bands, high lights and shadows, and by direction of stroke.

Examples of such quantitatively precise, three-dimension, bona fide maps in color are the maps of Spring Mill State Park, and of the Navajo Country, by the author.

A Study of Population Trends in Pike County, Indiana. Lowell I. Dillon, Indiana University.—Pike County, Indiana, suffered a loss of population every decade since 1900 except for the 1930-1940 period. Preliminary investigations show that this was a regional response until the 1940 census, as population graphs of the neighboring counties are rather similar up to that date. From 1940 to 1950, however, the decline seems more local, since surrounding counties made slight or substantial gains, whereas Pike had a twelve per cent loss.

The general area losses appear to reflect farm mechanization, inability of farmers on sub-marginal land to compete with those of more favored areas, loss of soil fertility due to erosion and strip coal mining, the change from shaft to strip coal mining, and the rural to urban trend associated with industrialization.

During the 1940-1950 decade, the most important reason for the dissimilarity between Pike and its neighbor counties seems to be lack of local industrialization. In 1947, Pike had less industry than any other southern Indiana county except Brown and Switzerland. Probably the second major reason was a locational one. Pike County is farther from Evansville than are Gibson and Warrick Counties, and thus less favorably located for commuting to this major southern Indiana industrial center.

Geologic Control of Ground-water Occurrence in Western Marion County, Indiana. Claude M. Roberts, U. S. Geological Survey.—Water-supply needs for both urban expansion and farm use have created ground-water problems in western Marion County, Indiana.

Thin, clayey glacial till of low permeability covers the shale bedrock of the area and locally contains shallow, thin lenses and streaks of water-bearing sand and gravel. Yields from the sands and gravels range widely from place to place; the water is usually of suitable quality. The shale retards the downward movement of water and serves to confine any water present in the limestone beneath. The dense limestone of the area is considered a poor aquifer; it yields water containing hydrogen sulfide.

At several localities, however, deep wells penetrating a limestone formation yield small quantities of water containing little or no hydrogen sulfide.

Interesting Aspects of the Conglomerate-Sandstone Phase of the Glacial Deposits of Tippecanoe County, Indiana. Joseph S. Rosenshein, U. S. Geological Survey.—During a ground-water reconnaissance of Tippecanoe County, Ind., conglomerate and standstone were observed interbedded with unconsolidated glacial deposits. Outcrops of the consolidated deposits are present in the west, west-central, and northeast part of the county. These cemented deposits are associated primarily with the Wabash River and Wildcat Creek drainage. Locally the material forms resistant terrace levels. Greater thicknesses of sandstone were found in the central part than in the northeast part of the county. Both the sandstone and conglomerate are crossbedded. The deposits are underlain and overlain by a gray-blue clay; in some areas they are underlain by a compact maroon till.

Calcium carbonate is the primary cementing agent. In many areas the degree of cementation varies in both the horizontal and vertical directions. The better sorted material is more effectively cemented.

Springs are present at the contact of rock and underlying gray-blue clay. Associated with the springs are deposits of calcareous tufa. In the past the cemented deposits must have been an aquifer of some consequence, with progressive erosion of the material by the Wabash River controlling the ground-water levels. Apparently cementation occurred either during late Wisconsin time or early Recent time.

A Method for Mapping Permeable Zones in Glacial Till. PORTER E. WARD, U. S. Geological Survey.—Well-inventory data, water-level fluctuations, and well characteristics are being used to map sand and gravel zones in the till plains of southern Indiana. The data indicating greater productivity of wells are taken to reveal the presence of the more productive aquifers and are used, with caution, as evidence of the shape and continuity of these aquifers. The method must be applied with an understanding of its limitations; however, it is very useful in reconnaissance studies where precise geologic and hydrologic data are rare or unobtainable.

Some Examples of Geologic Control of Ground-Water Quality in Northwestern Indiana. REUBEN J. VIG, U. S. Geological Survey.—Two conditions worthy of comment were observed during a ground-water study in northwestern Indiana. The first concerns hydrogen sulfide in water pumped from shallow limestone aquifers; the second, the effect of geologic structure upon ground-water quality.

Hydrogen sulfide is usually present in ground water where the New Albany shale caps limestone. The shale, which is known to contain pyrite and some organic material, could be a possible source of the gas. In some sections of the area, hydrogen sulfide is present also in ground water when limestone is directly in contact with the glacial drift. This limestone contains quantities of organic matter and has pyritic zones from which hydrogen sulfide could be derived in the presence of underground water. If the source of hydrogen sulfide is in the limestone, a shale barrier could serve as an effective trap for the gas.

Analyses of water from Ordovician aquifers show that the dissolved-solids content is considerably higher than that of water from Cambrian aquifers. This difference probably is the result of structural control. Cross sections based on logs of deep wells indicate that the St. Peter sandstone, the chief aquifer of Ordovician age, pinches out against the Kankakee arch, thus trapping the water. The Cambrian strata, however, are continuous across the arch.

Status of Rural Zoning in the United States—1954. J. E. BECHT, Indiana University.—A study of existing laws and attitudes concerning

"Rural Zoning" is especially timely in view of current problems that have arisen from severe droughts plaguing large sections of the United States and, to a lesser degree, because numerous areas have been adversely affected by the "economic recession" which began early in 1953. The purpose of the study is to provide an estimate of the effectiveness of any land-use programs which might be undertaken to alleviate rural economic distress and to maintain or to restore land values.

Effective state-wide "Rural Zoning Laws" have been adopted by less than one-fourth of the states. Many of the states which have the greatest need for "Rural Zoning" lack adequate laws to cope with their agricultural, grazing and forest land-use problems. Most "Rural Zoning" laws currently listed in the statutes were adopted and accepted during the years 1932-38. By 1932 sufficient pioneer work in Wisconsin, reports by federal committees and recommendations by state and county planning groups provided patterns of concrete corrective steps that could be followed to improve economic conditions in areas of limited physical resources. However, by 1938 the nation was sufficiently occupied with world affairs so that most problem areas were provided with stimuli which temporarily alleviated their financial plight. Consequently, interest in "Rural Zoning," other than for restrictions connected with highway, suburban and airport construction, has waned and it appears as though much costly and time-consuming re-education will be necessary before the general public will again recognize the need for sound zoning laws to govern uses of agricultural, grazing and forest problem-lands.

Locational Patterns of Wholesaling Within Metropolitan Centers. JACK C. RANSOME, Indiana University.—Wholesaling establishments are concentrated overwhelmingly in downtown districts of metropolitan centers. Brokers and sales offices prefer sites near the financial district where credit and communications facilities are best developed. Such wholesalers compete favorably with other users for office building space. Their location affords maximum convenience to clients.

Wholesalers with storage cling mostly to the edges of the retail shopping district and migrate with it. They occupy old retail or residential areas of low rent and with low pedestrian densities. Often they form a buffer zone between retailing and railroads or the waterfront. Symbiotic relationships are seen between retailing and wholesaling and light manufacturing and wholesaling. As a wholesaling district becomes known for a commodity line, like wholesalers are attracted and the resulting community tends to have considerable locational inertia.

Transportation facilities are hampered in downtown areas because of narrow streets, traffic congestion, and the lack of adequate off-street parking for trucks and customer automobiles. A slow decentralization of wholesaling is occurring in metropolitan centers. The movement is proceeding along rail sidings and highways which lead out from the city. Wholesaling in outlying areas is oriented chiefly to the carload receipt of goods, abundant operating space relatively free from congestion, lower taxes, and the suburban market beyond ten miles from the city center.

Planning groups must anticipate a greater need for wholesaling office space in the metropolitan center, and should encourage cooperative warehouse and transportation facilities for outlying wholesalers.

Iron Deposits in Southwestern Indiana.[1] WAYNE M. BUNDY, Indiana Geological Survey.—Most of the iron deposits of Martin and Greene Counties are within the Mansfield formation (Lower Pennsylvanian), but small deposits also occur in the Beech Creek limestone (Upper Mississippian), Goethite, the major iron mineral, occurs as cementing material, concretions, bands along bedding planes, veins, irregular open space fillings, and plant replacements in sandstone and shale. Small replacement bodies of goethite commonly are present in limestone. Magnetite occurs as finely disseminated grains within the interior shells of concretions. Iron probably was precipitated in swamps and lagoons in early Pennsylvanian time. That iron was deposited in bogs is indicated by: (1) local occurrence, (2) relative abundance of associated plant fossils, (3) similarity of chemical analysis with other iron deposits known to be of bog origin, (4) presence of clay, similar in composition to underclay, and (5) abundance and probable syngenetic nature of the iron concretions. Widespread occurrence of shrinkage cracks and colloform texture suggests that iron was largely a colloidal precipitant. Electrolytes, micro-organisms, oxidation, and supersaturation may have been active in the precipitation of the iron.

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[1] Published by permission of the State Geologist.

Manufactural Geography of LaPorte, Indiana[1]

ALFRED H. MEYER and PAUL F. MILLER, Valparaiso University

LaPorte, a city of 22,000, is one of many industrial cities scattered throughout the northeast United States. Located on the eastern threshold of the Calumet industrial complex (Fig. 1), LaPorte reveals its kinship to the Calumet region in terms of manufactured goods, transportation, markets and raw materials. Approximately forty diversified industries employ about 11,000 workers at an annual industrial pay roll of $30,000,000. The greatest emphasis is upon the 10 machinery and 11 metal products plants (Fig. 2), as about 80% of total employment is in these various metal-related industries.

One and a half to two years ago LaPorte was a critical labor and housing area. The Chamber of Commerce and local industries stated then that no new industry was wanted, since additional plants would only aggravate the labor and housing situation. Because of the lack of sufficient male labor, labor demand was met through greater use of female help. In June, 1953, female help comprised 39.64% of total employment, an unusually high percentage.[2] This was wartime prosperity, however, since so much of local economic activity was based upon government contracts related largely to the Korean emergency. The industrial boom was, therefore, temporary and not indicative of what might be termed the normal industrial situation in LaPorte.

Manufactural LaPorte is currently experiencing a sharp readjustment. The data on employment trends graphically portray the decrease in area employment (Fig. 3). This decrease in industrial activity is due in large part to a return to peacetime conditions. The two war order plants in the vicinity, Whirlpool Corporation and Kingsbury Corporation, have reduced employment from 7,600 in June, 1953, to 2,760 at present. Yet another contributing factor to lessened industrial activity is the curtailment of government contract work to established local industry.

Historical Geography Perspective

Occupying a favorable topographic site and regional situation, the LaPorte locale was settled from early times by Indians, and subsequently by white settlers in the early 1830's. Bounded on either side by forests and prairies, LaPorte benefited by a diverse resource base. Hardwood and coniferous forests on the Valparaiso moraine to the north provided timber

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[1] This study is based on a field survey conducted by means of a questionnaire, personal interviews and local field observations.

[2] *Area Labor Market Letter,* January, 1953, Indiana Employment Security Division, LaPorte, Indiana.

Fig. 1—LaPorte may well be considered today the eastern "doorway" to the heavily industrialized Calumet region. Situated on the boundary of the Valparaiso Moraine and the Kankakee Outwash Plain, its early industries, sawmilling and flour milling, benefited from the timber on the moraine and the grain produced on the outwash plain.

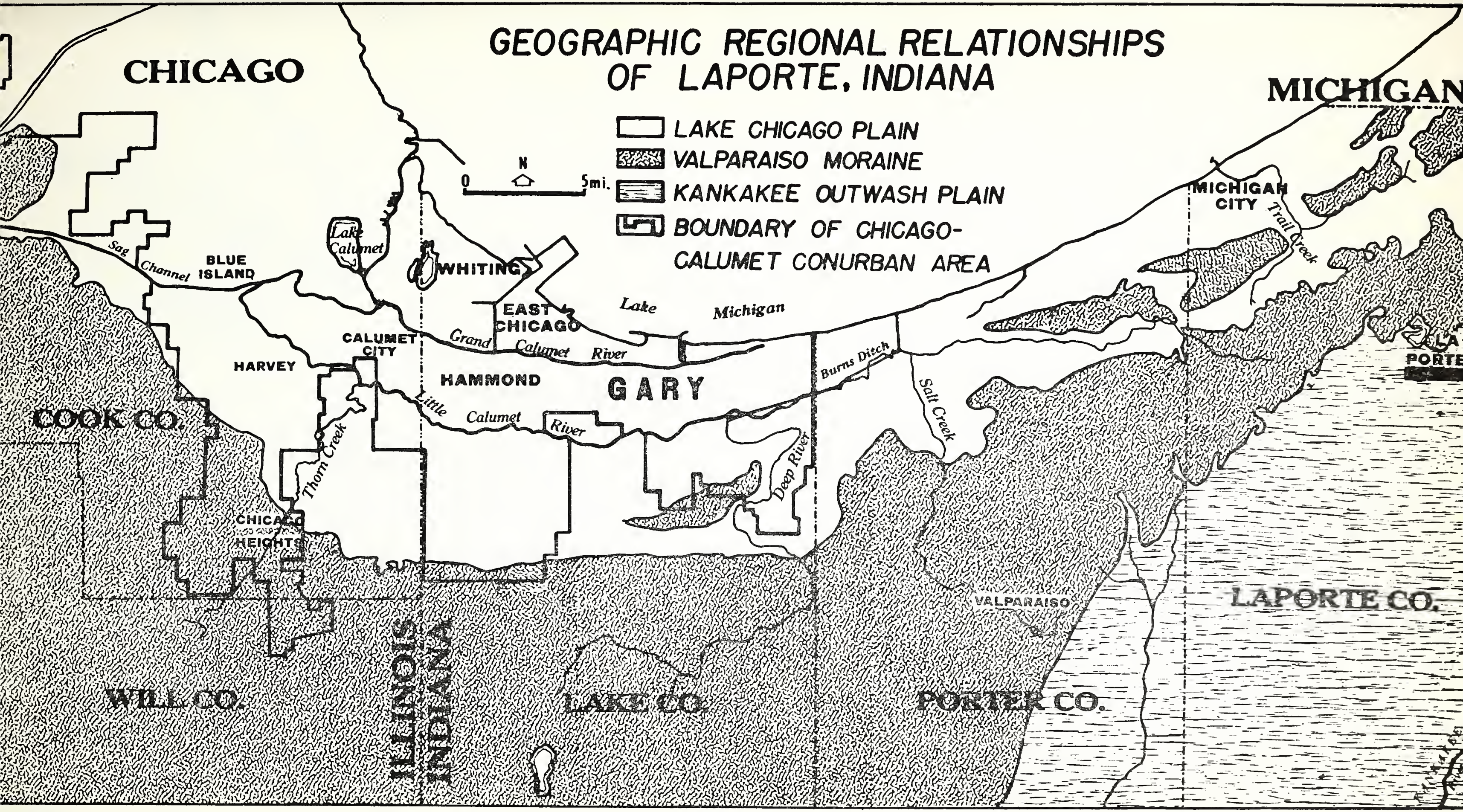
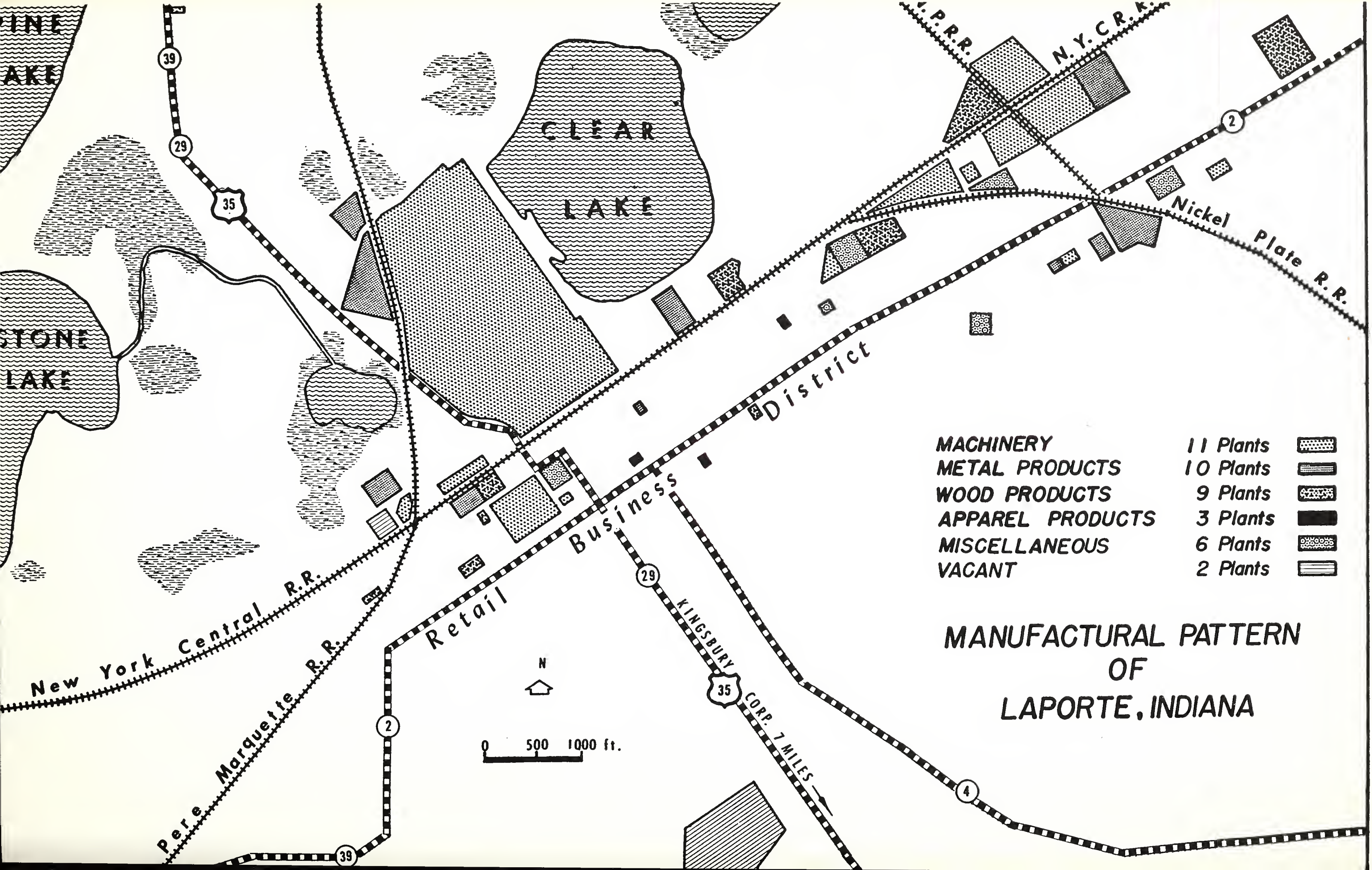

GEOGRAPHIC REGIONAL RELATIONSHIPS OF LAPORTE, INDIANA
LAKE CHICAGO PLAIN
VALPARAISO MORAINE
KANKAKEE OUTWASH PLAIN
BOUNDARY OF CHICAGO-CALUMET CONURBAN AREA
N
0
5mi.
CHICAGO
MICHIGAN
MICHIGAN CITY
Trail Creek
LA PORTE
Sag Channel
BLUE ISLAND
Lake Calumet
WHITING
EAST CHICAGO
Lake Michigan
CALUMET CITY
Grand Calumet River
HARVEY
HAMMOND
GARY
Burns Ditch
Salt Creek
Little Calumet River
COOK CO.
Thorn Creek
Deep River
CHICAGO HEIGHTS
VALPARAISO
LAPORTE CO.
WILL CO.
ILLINOIS
INDIANA
LAKE CO.
PORTER CO.

Fig. 1



MANUFACTURAL PATTERN OF LAPORTE, INDIANA for local sawmills and at an early date many woodworking establishments were in operation. To the immediate south, Door Prairie, on the flat and fertile Kankakee outwash, grew much of the grain that was processed in LaPorte, a leading pioneer flour-milling center (Fig. 1). Several lakes in the vicinity provided water, fish and recreation. Development of rail transportation at mid-century gave LaPorte stronger extra-regional business connections. With the aid of skilled German immigrants, the Rumely brothers started the agricultural implement industry, an industry which today is locally maintained by Allis-Chalmers.

Industrial activity in the latter half of the nineteenth century featured production of agricultural machinery, furniture, carriages and woolens. The first quarter of the present century witnessed the rapid development of the automotive industry. Although this caused the carriage works to disappear, it gave rise to new industries, especially the various metal manufactures which impinge upon the automotive industry. The Second World War gave further impetus to industrial growth, most of which was in metal-working establishments. In 1951 Whirlpool Corporation located its war order plant in LaPorte. In that same year Kingsbury Corporation, which had employed 22,000 workers in World War II, reopened under new management. The presence of these two plants in the LaPorte vicinity for the past three years has greatly disturbed the industrial climate of the city.

The Industrial Pattern

The pattern of LaPorte industry is closely related to the pattern of the rail lines (Fig. 2). Early industry established itself along the New York Central main line. More recent industrial development has been made at each end of the old linear industrial core. The newer industries have located at or near the intersection of the two branch rail lines with the New York Central. The eastern industrial subdivision, where the New York Central and the Nickel Plate cross, has experienced most of the recent development. This district probably will undergo further growth since level, vacant land is yet available on the eastern periphery of the city.

The western concentration of plants clusters around the junction of the New York Central and the Pere Marquette. This western district has limited potential due to adverse topographic conditions and the lack of undeveloped land. The huge Allis-Chalmers plant is located in part on a partially filled-in marshy tract. Because of deposits of silt, muck and quicksand this company uses no greater than 1,000 pounds loading per square foot.

It can be seen, then, that the local pattern of industries is similar in shape to that of a dumbbell. The two distinct districts to the east and west are connected by a linear arrangement of non-contiguous industrial sites along and between the New York Central and State Highway 2. Certain

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Fig. 2—On the basis of the code classification of Manufactures by the U. S. Department of Commerce, at least 35 different types are represented in the plant pattern here shown. For mapping purposes these have been reduced to five generalized classifications. Three industrial sections are recognizable : an eastern and a western compact area, each tied to two railway lines, and a central section of smaller, isolated plants.

smaller concerns are scattered throughout the commercial district and the neighboring residential areas. Kingsbury Corporation, using a LaPorte address, is located at the intersection of U. S. 6 and 35, seven miles south of LaPorte.

Manufactural Groups

Metals—As already noted, those varied industries which are based upon metals are predominant in LaPorte. The five largest local plants are all metal-working enterprises. Kingsbury Corporation produces many types of munitions, Allis-Chalmers manufactures farm machinery, Whirlpool makes washing machine parts, Bastian-Morley produces water heaters and boilers, and the U. S. Slicing Machine Company is the world's largest manufacturer of slicing machines. A further breakdown of this general group includes Modine Manufacturing Company which makes automotive radiators; the DeLuxe Products Corporation, producer of oil filters and pistons; the New York Blower Company, which manufactures unit heaters and ventilating systems; and the Coleman Company which makes water heaters. Besides these distinctive factories, there are four machine and tool shops, two foundries and seven fabricators of various metal products. When this general metal group is more specifically categorized, the machinery producing plants emerge as the single dominant type of manufacturing in LaPorte. A wide range of metal fabrications comprises the bulk of the remaining metal-related establishments. Rather than being concentrated anywhere within LaPorte, these plants are indiscriminately scattered throughout the city's industrial belt.

Woodworking—Illustrating historical continuity of an industrial tradition are a number of plants having wood as their chief raw material. None of these plants employs more than 250 persons, and the group utilizes only 8% of total LaPorte employment. Most of these present plants can be traced back to furniture factories and carriage works. Included in this list of woodworking industries are a sawmill, three furniture plants, two picture frame factories and a sash and door works. Although these plants have long since outgrown the local timber resource, some rough-cut timber is supplied by the local sawmill.

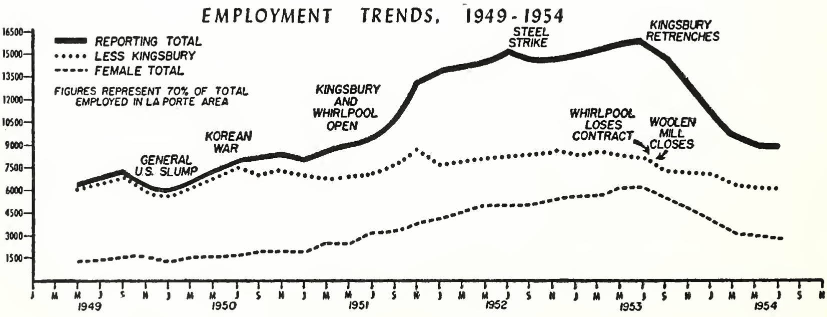

Fig. 3—The variable amount and kind of employment in LaPorte manufacturing industries, as here shown, are reflective largely of extra-regional influences. (Data supplied through courtesy of Gale K. Hess, Manager, Indiana Employment Security Division.)

Apparel—The apparel industry is locally represented by three concerns of modest size. This is an established local industry, and A. B. Coddington Garment Company mentions as one locative factor the presence of a labor pool of skilled needle workers in LaPorte. Until last year, the textile industry was represented by the LaPorte-Bachman Woolen Mills. The closing of the mill in the third quarter of 1953 corresponded to the beginning of the present slump in local manufacturing (Fig. 3). As two-thirds of the mill's business was automotive upholstery, the general slowup in South Bend and other centers directly affected their textile output. The three apparel establishments, not needing bulk transportation, are located away from the railroads in the general downtown area.

Miscellaneous—The much diversified list of local industries is featured by such distinctive concerns as a rubber products plant, a plastics company, a bookbinding establishment and a manufacturer of florists' supplies. The Ove Gnatt Company, the producer of florists' supplies, is one of the three or four of such plants in the United States. It occupies an old three-storied building which it took over in 1918 from a carriage works. In this connection it is interesting to note that LaPorte was a center of carriage and wagon production. The several shops included one owned by the Studebaker Brothers of South Bend.

Related Elements

Labor—At present 10,000 to 11,000 persons find employment in LaPorte's industry. This is a large number for a city of 22,000 people. Many of the total employed come from the surrounding area, since LaPorte is the job center for the greater part of two counties, Porter and LaPorte, plus portions of other adjacent counties. This tributary area is mostly farm land containing a few small towns and villages. The extensive labor source area extends 70 miles south to Monon, eastward to South Bend, northward into southern Michigan and westward to Gary-Hammond.

South of the Valparaiso Moraine, on whose southern margin LaPorte is located, there is an east-west belt of small communities partially inhabited by immigrants from Kentucky and Tennessee. These people moved into this area during the Second World War, attracted by high-paying jobs in northern industrial cities. The slowdown in local industry, especially at Whirlpool and Kingsbury, since mid-1953 has left many of these people unemployed. Being semi-transient, some have filtered back to their home states.

Female help which comprised almost two-fifths of those employed in the first half of 1953 was utilized to a great extent during the period of critical labor and housing. This subsequent slack period has witnessed a reduction in the percentage of women employed in local industry. Kingsbury and Whirlpool employ a high percentage of female help. Although Kingsbury is seven miles south of LaPorte, approximately 20% of the labor force resides in LaPorte.

LaPorte has for long had a tradition of skilled labor, especially in the metal-working industries. A number of industries interviewed reported that skilled labor has been one of the more important attractions to industry.

Transportation—LaPorte has excellent transportational facilities that allow for fast, convenient local, regional and extra-regional connections. From early times people passed through this locale; first the Indian on the famous Sauk Trail, then the white settler on wagon trail and railroad. During the rapid railroad development around mid-centudy, several rail lines went through and near LaPorte. The Michigan Central Railroad was completed in 1850, the Lake Shore and Michigan Southern in 1852, the Louisville, New Albany and Chicago Road in 1853 and the Nickel Plate in 1854. Three rail lines serve LaPorte today: the New York Central, the Nickel Plate and the Pere Marquette. Several other major rail lines are within close proximity.

The excellence of the highway net facilitates movement to and from LaPorte. Entering the city, itself, are State Roads 2, 4, 29 and 39, and U. S. 35. Within a short distance of the city these routes connect with such major routes as U. S. 6, 12, 20 and 30. Serving industry on these various roads are seven local trucking firms. Overnight service is provided to the large cities of this midwestern area.

One of the most promising factors for LaPorte's future industrial welfare is the close proximity of a proposed toll road. Only one and a half miles northwest of the city's limits, the toll road will allow 24-hour trucking service between LaPorte and New York City.

Raw Materials—LaPorte, with diversified industry, has a diversified material source area. The variety of materials comes from a variety of geographic sources, mostly from the United States, but some from offshore. LaPorte's dependence upon the Calumet region is manifest in the high percentage of steel and metal parts procured in this industrial complex. Local firms producing castings, machine parts, tools and dies market much of their product in LaPorte, and nearly all of it within the Calumet region. Most of the timber used comes from the South and far West, although some lumber is produced in the vicinity. The great majority of the city's industrial material needs are met in the Calumet region and the northeastern quadrant of the United States. More than one concern stated that the nearness of requisite materials was a major consideration in locating in LaPorte.

Markets—Diversity in types of manufacturing serves to explain the diverse geographical spread of LaPorte's markets. Some products, like agricultural machinery, furniture and automotive supply, have a midwestern distribution. Products such as florists' supplies, blowers and water heaters, slicing machines and picture frames are more commonly marketed nationally. A certain few products enter the foreign market. Conveyor belts, florists' supplies, slicing machines and 10% of hot water heaters have international sale. This brief description of the geographical distribution of LaPorte's markets points to the mature, extra-regional aspect of much of the local industry.

Trends

The industrial health of LaPorte depends, of course, upon the economic well-being of the entire United States. The presence of two war order plants in the vicinity haunts LaPorte with the specter of periodic industrial maladjustment. Presently Whirlpool, with greatly curtailed employment, is doing comparatively little government contract work. Such work is also at a minimum at Allis-Chalmers and the U. S. Slicing Company. Kingsbury Corporation is operating with a greatly reduced total of 2,300 employees.

Present unemployment has been somewhat eased by the gradual drifting south of people originally from Kentucky and Tennessee. To further alleviate the situation the Chamber of Commerce is waging a campaign to attract new industry. The Chamber of Commerce has attracted industry to LaPorte in the past 35 years; new success in their present campaign is entirely possible. The most recent labor analysis of the Indiana State Employment Service in LaPorte indicates that the downward trend in employment has been arrested.[3]

But long-range stabilization and systematic development of industry must necessarily depend upon a far-sighted program in industrial zoning and planning.

Industrial Zoning and Planning

Most sizable cities now recognize the fact that industrial and commercial enterprises are needed to develop a sound community economy; hence such organizations as the Chamber of Commerce, the various manufacturers', merchants' and employment associations and the City Plan Commission. The first agencies are concerned primarily with the immediate day by day problems and programs of the community, whereas the City Plan Commission has for its chief objective the formulation of a sound geographic pattern of form and function for the all around social and economic development of a community for decades to come.

It appeared essential therefore, in a geographic survey of this type to include this inquiry in our questionnaire: "Are local and regional zoning and geographic planning ordinances adequate to meet all the needs of your plant for present operations? For anticipated future expansion? Comments."

Only a 27% response was received on this question. Five respondents gave an unqualified "yes" to the question of present-day adequacy. Two comments: "Yes, probably; we have no critical problem at this time" and "We are located near the center of the business shopping district in an area where zoning ordinances would not permit us to operate had we not been here when the ordinance was passed."

Because of the low percentage return on this part of the questionnaire, the response on this point does not reflect an adequate overall community appraisal of geographic site criteria suited to the development of the total present industrial pattern and the future industrial expansion program. Accordingly, several observations by Mr. Nelson Hazzard, President of the City Plan Commission of LaPorte, prove very helpful in understanding the situation:

> 1. The areal pattern zones for industry by the City Zoning Ordinance of 1933 has proven inadequate in recent years to meet

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[3] *Area Labor Market Letter,* August, 1954, Indiana Employment Security Division, LaPorte, Indiana.

the needs of a growing industrial community like LaPorte. Some of the sites remaining are too small to accommodate large plants.

2. One of the problems consists of needed expansion of certain existing industrial sites into undesirable terrain areas such as are found in the marshy tracts on the southwestern and western industrial district.

3. On the other hand, terrain suited to industry and zoned for such, as in the section adjacent to the New York Central about one-third mile east of its juncture with the Nickel Plate, has come to be preponderatingly residential, over three score houses now occupying the area.

Still another industrial site situation is reflective of the condition of earlier days when there was no zoning at all, or "spot" zoning since the Zoning Ordinance was adopted in 1933, in either case resulting, as in the central district, in a fragmented industrial pattern.

As a result of these and other recognized civic needs for the systematic future development of the Community, the City Council of LaPorte is now considering the adoption of the Master Plan proposed by the City Plan Commission. Based on thorough surveys and extensive public hearings, this projected geographic pattern points to a new period of progressive residential, commercial, and industrial development.

As for industry itself, the theme of this paper, several new large sized tracts, geographically well oriented, are being proposed: one at the northeast extremity of the city, north of the intersection of the Nickel Plate and the New York Central; the other, on the southwest extremity between the Pere Marquette and the New York Central.

What the newly modified industrial zone pattern will look like is revealed in Fig. 4.

Conclusions

If there is a minimum of periodic fluctuation in local government contract work, LaPorte's industry should fare as well as the national economy allows. This ever-present variable of contract work will, however, determine the local short-run manufactural situation.

LaPorte has a century-old tradition of manufacture, and her regional position in relation to raw materials, semi-processed goods, labor and markets is advantageous to the maintenance of such a tradition. LaPorte, the eastern entry-way to the Chicago-Calumet complex, is astride the funnel of major east-west rail and road routes which converge onto the greatest railway center of the United States. In close proximity to the markets and facilities of the Chicago-Calumet area, LaPorte suffers none of the disadvantages of congestion of those metropolitan centers. The projected toll road will serve to strengthen LaPorte's commercial relations with the manufacturing and market areas to the east and to the west.

In spite of the recent fluctuation in local industrial activity, a note of stability is provided for manufactural LaPorte by the presence of established industries couched in the geographic advantages of the city's total situation. But it will require long-range planning, now apparently assured

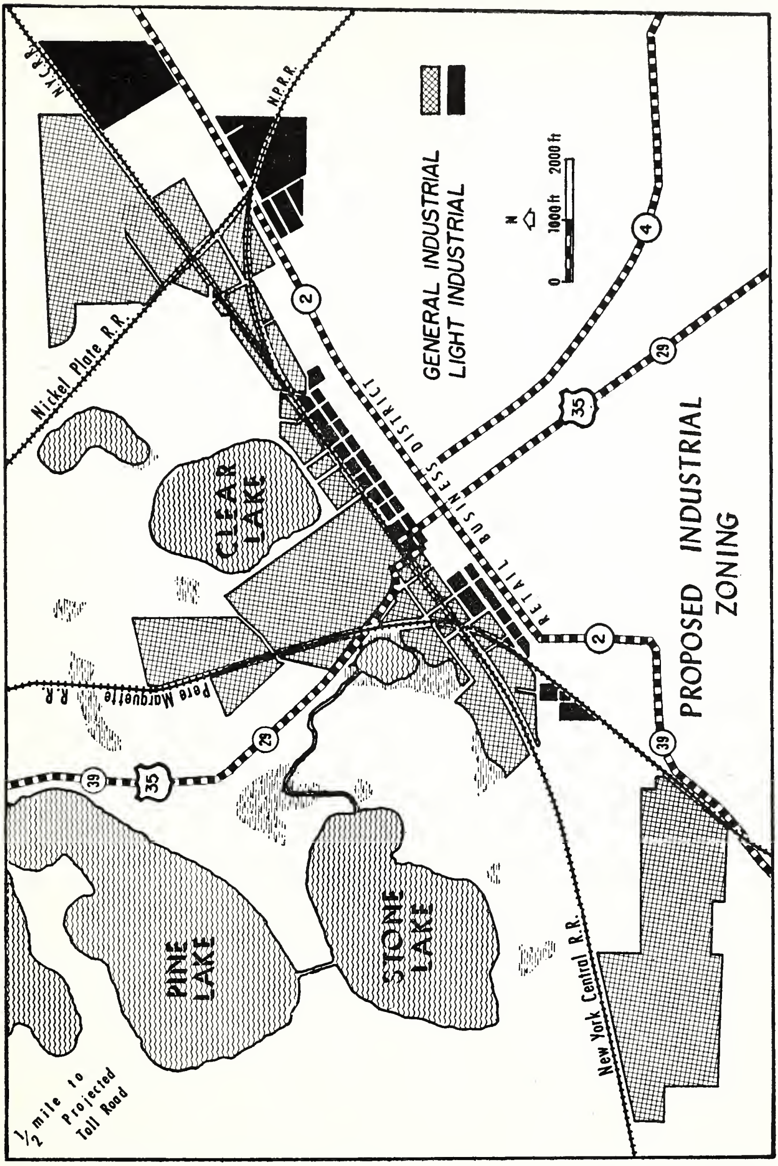

Fig. 4—The presently projected Master Plan of the city of LaPorte proposes, among other changes in zoning, an expansion of areas zoned for industry, which would assume the spatial relations shown above.

through the prospective adoption of a Master Plan, to realize fully these potential benefits.[5]

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[5] Grateful acknowledgments are due the many individuals and agencies who have contributed significantly to this study. These include:

The individual plant managers who responded to our questionnaire: the LaPorte Chamber of Commerce, which supplied general manufactural data; the Indiana Employment Security Division, which supplied data on employment trends; Nelson Hazzard, President of the City Plan Commission, who contributed map and other data on the proposed Master Plan; Robert E. Kellner of the Sanborn Map Co., who granted the privilege of consulting the Sanborn atlas; and Stanley Showalter, Insurance Agent in LaPorte, who extended the courtesy of checking Sanborn map data in his office.

A Study of Areal Specialization in Sullivan County, Indiana

R. C. Mayfield, Indiana University

There is no basis for presenting Sullivan County as a homogeneous regional entity, other than that of political definition. It is included, however, in numerous and diverse "regional" units, each of which contributes factors to the spatial arrangements and associations within the county. Location in the Wabash Lowland and Eastern Interior Coal Field has been of special significance to the development of Sullivan's predominating areal specializations—agriculture and mining. Other industry, commerce, and settlement have been affected by fluctuating conditions of the two principal industries.

Agriculture—The Major Land Use

Approximately 80 per cent of the county's total area is in farm land. The average farm size here, 110 acres, is slightly below the state average, yet relatively few Sullivan farms are near this mean. An increase of 30 acres in average farm size since 1935 may be attributed, in part, to the following factors:

1. Mechanization, increasing the number of acres that a farmer can operate efficiently.
2. Increased purchasing power of small farm operators through sales of oil, gas and coal mineral rights.
3. Savings from the wartime boom in coal mining employment.
4. A general farm prosperity in the area.

Commercial farming in Sullivan County is led by cash grain and livestock farms, both of which are more numerous than the "general" farm, which largely combines the two types. A once profitable fruit industry has declined, due to:

1. Early arrival in the market area of peaches and other fruit from southern states.
2. The late arrival of high quality apples from Michigan in a season more comfortable for home canning.
3. Inroads on the deciduous fruit market by citrus fruit through continuous advertisement.
4. Increased production costs, chiefly that of labor.

The significance of non-commercial farming here is reflected in a modal farm size for the county, in 1950, of less than 50 acres for over 900 farms. A large number of these are operated by coal miners in slack seasons. Too, employees of local gravel and sawmill companies rarely work full time, and usually supplement that income by farming. Many commuters to industrial employment outside the county utilize after-work hours and other free time in farming.

Poor farming practices accompany part-time farming in Sullivan. Most of the operators have little or no mechanized equipment to facilitate terrace building, accurate contour plowing, or farm pond construction—three especially suitable practices for the relatively poor land which characterizes the part-time farm here. Indeed, county-wide improvement of farming methods and adoption of conservation practices is needed. Farm operations on relatively unproductive and highly erosive land, especially in the northeastern and east-central portions of the county, give rise to a need for rural zoning and other local stimulations to out-migration.

Coal and Sullivan County

Although a predominately agricultural county today, Sullivan's peak growth was attained by expansion of coal mining activity. Present status of the industry here is a depressed one. The largest of the underground mines are in direct competition with local strip mines for the same market—power plants in the Chicago-Milwaukee area. Seasonality of operations is partially imposed by an increasing power plant conversion to natural gas during the summer when domestic gas consumption is low. Actual depletion of workable veins of good quality has been a factor in the decline of underground mines, as has been the closing of unionized mines that reopened in states with less rigid labor laws. Stages of decline in the local coal industry have released more workers than other county industry could absorb.

Transportation and Trade

Although Sullivan has experienced little industrial development other than its long-depressed coal mining, it is situated near counties of industrial growth. An extensive transportation net has provided accessibility to plants outside the county for a large number of commuters. Terre Haute, Vincennes, Crane and Bloomington attract a heavy majority of these workers.

Virtually legislated into a central-place function, the county seat serves most of Sullivan. A radial pattern of townships around the county seat is similarly marked by a radial pattern of characteristically small urban settlements, each acting as limited commodity exchange and service centers for adjacent areas. Of all the urban settlements, only the city of Sullivan, the county seat, has maintained a population as great as that of 1910, the year of peak census tabulation for the county. This gain by the county seat has generally been little more than could be credited to natural increase.

Non-taxable Land

Of increasing concern to the county is the removal of large tracts of land from its tax rolls. By the donation of strip-mined areas to the state, some coal companies have shed themselves of a reforestation or reclamation burden as well as a continued county tax assessment. As legislation requiring full reclamation by the open-cut operators does not seem forthcoming, the county is faced with a continued loss of both the productive capacity of the farm land so mined and of the potential tax revenue. A workable arrangement might be made whereby the county shares the reclamation expense, and in turn receives the land which would otherwise be given to the state. Resale would help compensate the county, as would the permanent contribution in county taxes.

Summary

A geographic examination of Sullivan County reveals two predominating areal specializations, both with major problems. Facets of their relationships to the county have alternately encouraged and discouraged economic and physical growth.

Geologic Structures in the Coal City and Switz City Area of Indiana

FRANK E. KOTTLOWSKI, Socorro, New Mexico

Introduction

Coal beds and the adjacent associated strata, such as are exposed in the Coal City and Switz City area, exhibit an unusual diversity of structural features and sedimentary unconformity. Recognition and interpretation of the structures are of economic benefit in the exploration and mining of coal, in the search for oil and gas, and in the quarrying of sandstones, limestones, shales, and clays within the coal-bearing formations.

The Coal City and Switz City area is on the eastern edge of the coal fields of southwestern Indiana and is about 30 miles southeast of Terre Haute (Fig. 1). The area lies within two physiographic divisions of Indiana, the western part in the Wabash Lowland and the eastern part a fringe of the Crawford Upland. Narrow ridges separated by wide expanses of alluvial bottomlands are characteristic of the topography.

The field work in the area was done during 1949 and 1950 for the Coal Section of the Indiana Geological Survey. This paper is published with permission of the State Geologist, Dr. Charles Deiss, and has been reviewed by Charles E. Weir, head of the Coal Section.

Stratigraphy

The rocks exposed in the Coal City and Switz City quadrangles are Lower Pennsylvanian and Quaternary in age. The upper part of the Mansfield formation, the Brazil and Staunton formations, and the lower part of the Linton formation crop out (Fig. 2). The nearest Mississippian rocks, of the Chester series, crop out below Mansfield sandstone beds four miles east of the quadrangles. Quaternary sediments are Illinoian till and Wisconsin proglacial deposits that overlie the bedrock and so blanket the area that outcrops of the Pennsylvanian rocks are limited to strip pits, road cuts, and deeply eroded stream valleys.

The basal Pennsylvanian Mansfield formation overlies Mississippian rocks with a pronounced erosional unconformity east of Switz City but only the upper 30 to 45 feet of the formation crops out in the mapped area. The formation in drillings ranges from 152 to 266 feet in thickness, averaging 210 feet. The beds are characteristically light-gray to gray, cross-laminated, ripple-marked sandstones that weather to rust-brown honeycombed bluffs. The upper one-fifth of the formation is locally a blue-gray shale. A thin dark-gray limestone and associated black shales occur in places near the top of the Mansfield formation and are probably correlative with the Ferdinand limestone of southern Indiana (2). Lenses of minable coal are locally present at several horizons within the Mansfield formation.

The Brazil formation is divisible into eight units, from base upward, as follows: (1) the Lower Block coal, which averages about 2 feet thick, (2) blue-gray to gray shale with thin sandstone laminae, 9 to 36 feet thick, (3) the Upper Block coal and its underclay, 3 to 7 feet thick, (4) a hard gray sandstone overlain by a gray sandy concretionary shale, 15 to 36 feet thick, (5) the Minshall coal and its underclay, several feet thick, (6) black to dark-gray shales and the Minshall limestone; the lower shales are 5 to 16 feet thick, the limestone 2 to 14 feet thick, (7) gray sandy shale and light-gray sandstone, about 12 feet thick, (8) Coal II, about 6 inches thick.

In many places the upper beds of the Brazil formation were removed

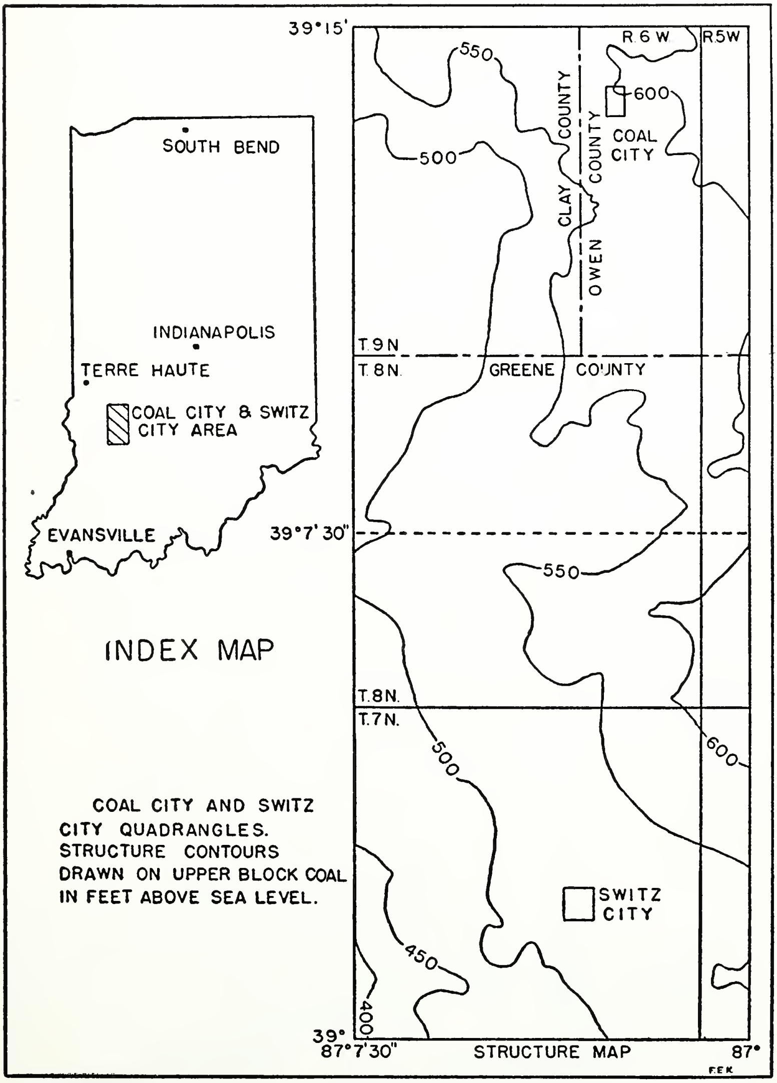

FIGURE 1.

by erosion, and the basal sandstone of the Staunton formation rests on the Minshall limestone or lower horizons.

The Minshall coal and limestone are named after the small village of Minshall in south central Parke County, Indiana. The limestone and coal crop out in the bluffs and ravines near Minshall, but no connected section is exposed, therefore the type section is taken partly from mining information. A section near Minshall is as follows, from outcrops and from Ashley (1):

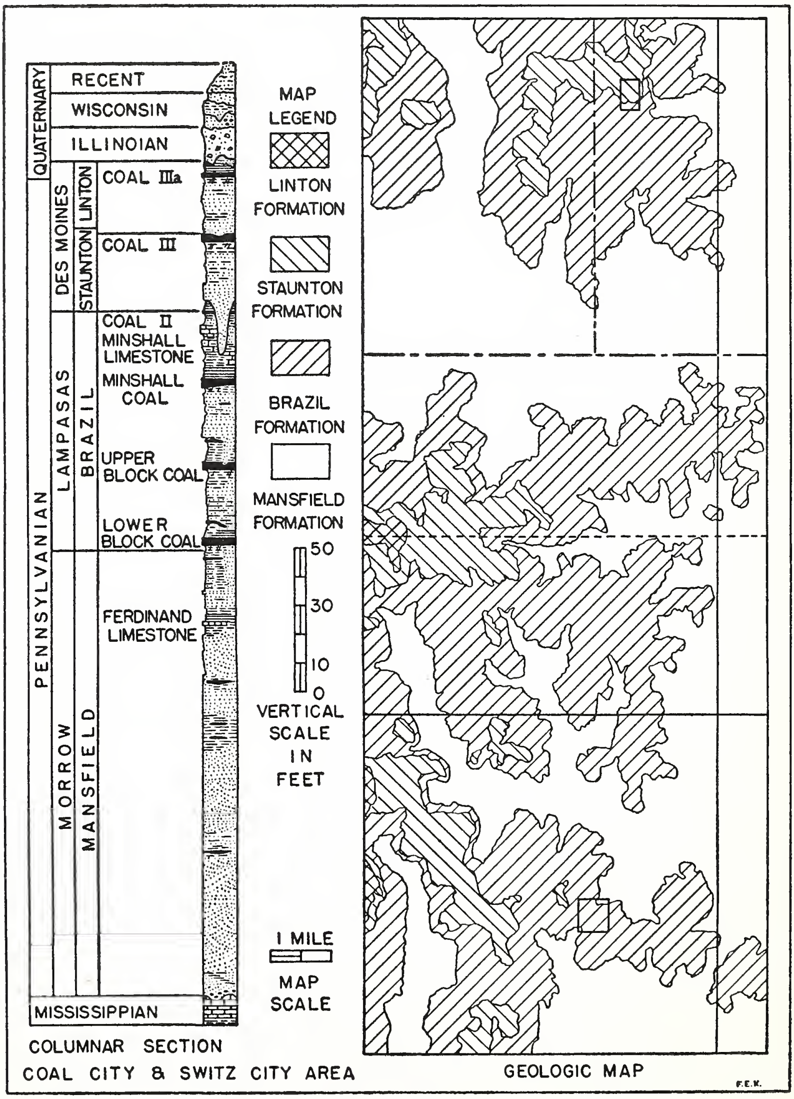

FIGURE 2

NW¼ sec. 17, T. 14 N., R. 7 W.:	Feet
8. Shale, sandy; locally shaly fossiliferous limestone lenses near base	30 plus
7. Upper Minshall coal, or Coal II, semi-block	1.0–3.2
6. Clay, light-gray	2
5. Shale, blue	8–18
4. Minshall limestone, blue-gray, thick-bedded, cherty, fossiliferous	2–3
3. Shale, black, sheety	3–14
2. Minshall coal, semi-block, dull, some pyrites	3.7-5.5
1. Underclay, gray to dark-gray	4–5

NW¼ sec. 35, T. 14 N., R. 7 W., Superior No. 2 Shaft:	Feet
6. Shale, dark gray, beneath underclay	6–2
5. Upper Block coal	4.3–5.1
4. Fireclay, lower part concretionary	4–5
3. Shale, sandy, brownish-gray	16
2. Shale, brown, blocky	10–12
1. Lower Block coal	2.0-4.5

The fauna of the Minshall limestone near Coal City is characterized by the brachiopods *Marginifera haydenensis, M. wabashensis* and by *Fusulinella* sp. therefore appears to be of Lampasas age. The Minshall limestone correlates with the Seville limestone in western Illinois and the lower Mercer limestone in Ohio.

The Staunton formation is 19 to 55 feet thick in the Coal City and Switz City quadrangles where it can be differentiated. The basal member is a light-gray, cross-laminated, micaceous, massive sandstone which varies greatly in thickness as it fills channels and depressions on a pre-Staunton surface. The sandstone is overlain by blue-gray sandy shale which underlies the underclay of Coal III. Coal III is 2 to 5 feet thick in the areas where it has not been cut out below the erosional surface at the base of the Linton formation.

The Linton formation is about 65 feet thick to the west but only the basal 30 feet occurs in the Coal City and Switz City quadrangles beneath the Quaternary glacial deposits. The basal bed is a light-gray micaceous sandstone, about 20 feet thick, overlain by gray clay shale that underlies Coal IIIa. Coal IIIa averages less than one foot thick and is overlain by 2 to 4 feet of marine black shale. To the west the black shale grades up into the thin Oak Grove limestone, and the limestone is overlain by a sequence of sandy shales capped by Coal IV.

The Pennsylvanian bedrock is covered by a blanket of Illinoian glacial till 4 to 82 feet thick. Till fills a buried pre-glacial valley in the northwestern part of the Coal City quadrangle, as indicated on the geological bedrock map (Fig. 2) by the thin strip of the Mansfield formation 2 to 3 miles west of Coal City. Valley train and lake sediments were deposited in the valleys during early Wisconsin time, and eolian sands and silts were blown onto adjoining uplands.

Figure 2, the geologic map of the bedrock in the Coal City and Switz City quadrangles, reflects: (1) the west-southwest dip of the Pennsylvanian beds, (2) the topography, (3) the distribution of glacial deposits and of pre-glacial valleys.

Regional Structure

The quadrangles are on the eastern edge of the Eastern Interior Coal Basin. The sedimentary beds dip west-southwest to west 15 to 40 feet per mile (Fig. 1). Small, irregularly distributed folds of the plains type interrupt the regional dip at many places. These anticlines, domes, noses, and basins increase in steepness downward, typically occupy less than one square mile, and have vertical closures ranging from 30 to 100 feet. Sandstone lenses in the coal-bearing rocks caused many small anticlines by differential compaction. The vertical closures above these lenses are rarely more than 20 feet.

The northern part of the Indiana coal field, from Vermillion County to Sullivan and Greene counties, is in a minor shallow syncline which is separated from the rest of the Eastern Interior Basin by the LaSalle anticline. The Block coals, Coal III, and Coal IV are thicker and more persistent in this syncline than anywhere else in the basin. The syncline was a controlling factor in the deposition of these older coals as is indicated by their areal extent.

Local Structures

Local structures include two types: (1) primary structures, (2) secondary structures. Primary structures are those due to deposition or erosion during Pennsylvanian time contemporaneous with sedimentation. These are called inorganic mechanical structures by Pettijohn (6). Secondary structures are those due to tectonic movements after lithification of the rocks and are usually of post-Pennsylvanian age in the area.

Primary Structures—Structures due to deposition or erosion during Pennsylvanian time are widespread in the mapped area. Southwestern Indiana was part of a low, uneven, coastal plain during most of Pennsylvanian time, and in depressions on this surface coal swamps formed. The lenticular character of the Lower Pennsylvanian coals suggests that most of the persistent coal swamps during the time were relatively local. Thin, impure limestones and associated black shales were deposited when the coastal plain sank below sea level, with thicker deposits being formed in the deeper coal basins. Post-Staunton coals, such as Coal V, are at least 3 to 5 feet thick over hundreds of square miles because they were deposited in larger shallow depressions.

An analogous situation might be the present-day Dismal Swamp in North Carolina and Virginia, a fresh-water swamp, which lies on the Atlantic Coastal plain with its surface only 5 to 25 feet above sea level (7). It covers an area of 2,200 square miles, and contains an average of 7 feet of peat. The lenses of thick Brazil coals in Indiana cover much smaller areas and their distribution indicates a more or less continuous swamp in southwestern Indiana with the thicker lenses deposited in the deeper depressions. The block coals contain more durain and cannel coal than later coals, therefore are composed of the smaller and more resistant fragments of plants. These resistant vegetal portions collect in open water (5) and would tend to be concentrated in local deeper basins.

Pennsylvanian rocks in the Eastern Interior Basin record the rhythmic advance and retreat of shallow sea waters in which thin limestones and marine shales were deposited. Absence of the sea was marked by the spreading of terrestrial sandstones and shales, by the establishment of large coal swamps, by the development of underclays which in most cases were poorly drained soils, and by the deposition of freshwater limestones. Widespread unconformities mark the pronounced changes in sea level in contrast to local unconformities which occur at the base of most Pennsylvanian sandstones and are produced by the streams that deposited the sandstones.

The coals were originally deposited as masses of vegetation in swamps, the plant material was compacted to peat, and the peat under pressure of superimposed sediments lost water and gases until coal was formed. The plant material is compressed ⅛ to 1/20 of its thickness to form coal. Before compaction the swamp basin is filled by peat to a level surface. After compaction the top of the coal bed in the center of the swamp is lower than the top of the coal bed around the margins of the basin. The margins of the coal basins, therefore, are indicated by coal beds that dip upward away from the lower parts of the basin and that thin away from the center of the basin. The margin of an Upper Block coal basin is exposed in the west highwall of the strip pit in the NW¼ sec. 23, T. 9 N., R. 6 W. where the coal bed dips steeply south and thins to the north.

Locally sand bars were deposited by streams in the pre-swamp basins. These sandbars were only partly buried by plant material and were preserved as ridges over which the coal is thin or absent. Many of these ridges, called horsebacks by the miners, occur in the small mines southeast of Coal City in Sec. 24, T. 9 N., R. 6 W. A typical horseback is exposed in the Commadore strip mine beneath the Minshall coal north of Coal City.

Local partings are common in the coals of the Brazil formation. Splitting of the coals into benches separated by thick clay, shale, or even sandstone partings has caused much confusion in correlation and locally has made mining costly. Many of the younger and more extensive coals, such as Coals III, IV, and VI, have clay partings that are present throughout most of the Indiana coal field. The partings in the Brazil coals are local lenticular beds of shale or sandstone deposited by streams during a brief pause in the deposition of plant material in the coal swamps. A 0.4 to 1.1 foot shale bed that grades laterally into sandstone is present in the middle of the Lower Block coal in outcrops along the ravine in NW¼ sec. 13, T. 9 N., R. 6 W. Two thick shale partings occur in outcrops of the Upper Block coal in the west bank of the ravine in NE¼ sec. 10, T. 8 N., R. 6 W. A thick sandstone and shale wedge splits Coal II into two thin beds near the east end of the well-exposed outcrops in the Illinois Central Railroad cut, Sec. 21, T. 7 N., R. 6 W.

Rock fillings of channels cut into coal beds are called rolls and crop out in the highwalls of almost all strip pits mining the Block coals. The channels either were cut after deposition and lithification of the coal bed or by open water currents during the deposition of the plant material in the coal swamp. Channel fillings contemporaneous with coal deposition are characterized by: (1) coal laminae that extend from the coal bed into the sandstone fill rock as discontinuous fingers, (2) the coal's usual roof extends over the channel fill, (3) the upper coal laminae in the sandstone fill bend upward from the coal bed. A contemporaneous channel fill of sandstone crops out in the east highway of the strip pit in SE¼ sec. 4, T. 9 N., R. 6 W.

Sandstones that fill channels cut after coal deposition are abundant. A large channel cut through and almost 15 feet below the Upper Block coal and is filled by sandstone in sec. 9, T. 9 N., R. 6 W. in the Commadore strip pit. Near the north end of the same pit small channels are filled by a bright reddish-brown, coarse breccia containing fragments of coal and carbonized plant imprints in a matrix of hematite-impregnated sand and clay. A channel sandstone is well exposed in the west highwall of the strip pit in NW¼ sec. 23, T. 9 N., R. 6 W. where the channel was almost 500 feet wide. Many smaller channel sandstones crop out in the highwall of the strip pit in SW¼ sec. 12, T. 8 N., R. 6 W. One side of the channel in many places is a steep bluff of shale against which the sandstone abuts.

Secondary Structure—Structures due to tectonic movements are not pronounced in the mapped area. A small reverse fault crops out in the southeast highwall of the strip pit in the SE¼ sec. 4, T. 9 N., R. 6 W. The Upper Block coal in the western footwall is dragged upward along the fault plane and in the eastern hanging wall is intimately shattered and thrust relatively westward 7 feet. The throw of the fault is 8 feet. A similar shallow Pleistocene overthrust was reported by Wier (9) southwest of Linton. A normal fault is exposed in the Illinois Central Railroad cut in sec. 21, T. 7 N., R. 6 W. Here Coal II is faulted as a result of differential compaction under a sandstone lense.

The gentle west or west-southwest dip of the Pennsylvanian beds in the area is interrupted by small domes, noses, and basins. Some of these structures are due to differences in deposition during Pennsylvanian time but in many places they reflect deeper structures. The most pronounced structural feature in the Switz City area is the terrace several miles west and southwest of Switz City (Fig. 1). The structure is partly concealed by unconsolidated deposits south of Switz City but two noses and a small dome are indicated by detailed structure contours (3). The steep dip west of the terrace is based on relatively sparse information. The low narrow structural ridge in the northern part of the Switz City quadrangle parallels a similar ridge in the southern part of the Coal City quadrangle (Fig. 1). The broad, irregular terrace near Coal City and the southward plunging nose in the northwest corner of the quadrangle are the chief structural units in the northern part of the mapped area.

The larger secondary structures are indicated by the contours on the structure map (Fig. 1) which are drawn on the top of the Upper Block coal because less error is introduced in calculating to its horizon from data on other coals. Actually none of the three main coals (Lower Block, Upper Block, Minshall) are too reliable as structural horizons as their elevations are partly controlled by sandstone lenses, by thickness variations of the rocks between the coal beds, and by the thickness variations of the underlying Mansfield formation. Shallow drillings to the Mississippian Chester formations, which are 125 to 325 feet deep, would give satisfactory structural control and would reflect structures in the petroleum-bearing Devonian formations.

To the west the younger more persistent coal beds reflect, in general, structures beneath the Pennsylvanian rocks, and are a valuable guide to petroleum-producing highs. The Wilfred pool in the Hymera quadrangle (10) and the Heien and Marts pools in the Shelburn quadrangle (8) are outlined by and were discovered from coal domes. Some of the folds, however, are the result of differential compaction around and over sandstone lenses within the Pennsylvanian rocks, such as the structural ridge in the northwestern part of the Dugger quadrangle (4) which is almost entirely due to a thickening of sandstones between Coal IV and Coal V.

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A Striking Example of Pre-Pennsylvanian Erosion in Orange County, Indiana[1]

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The most conspicuous erosional unconformity of a regional nature in the bedrock of Indiana is located between the Mississippian and Pennsylvanian systems. The regional aspects of the pre-Pennsylvanian unconformity have been pointed out clearly by Malott (3, p. 239-246) and formed the substance of the Fourth Annual Indiana Geologic Field Conference, which was led by Esarey, Bieberman, and Bieberman (1). Beneath the unconformity progressively older beds are truncated northward from the Ohio River. Consequently, in that part of Perry County near the Ohio River, the Mansfield (Pottsville series, Pennsylvanian) sandstone rests at places on the Kinkaid limestone, which is the youngest formation of the upper Chester (Upper Mississippian) group. Farther northward, the Mansfield rests on progressively older and older Chester rocks until, in the vicinity of Greencastle, Putnam County, the Mansfield generally rests on the Paoli, the oldest limestone of the Chester series, or on the Ste. Genevieve limestone of Meramecian (lower Upper Mississippian) age. Therefore, between the Ohio River and south-central Putnam County, the base of the Mansfield has descended through a stratigraphic interval that approximates 500 feet.

Chester rocks occupy a unique position in the geologic column because they are located stratigraphically between the predominantly calcareous Meramecian strata that may approach 600 feet in maximum thickness and rocks of the Pennsylvanian system which are composed largely of clastic materials. In sharp contrast with these younger and older rocks, the striking feature of the Chester series is the regular alternation of thin, generally fossiliferous, marine limestones and sparsely fossiliferous or typically unfossiliferous clastic formations. Chester limestones characteristically maintain their lithologic individuality over wide areas of outcrop; in contrast, the clastic formations of the series commonly show abrupt lateral and vertical variations in lithology. Because of the lithologic variability of Chester clastic rocks, their field identification is based largely on their stratigraphic position with respect to Chester limestones.

The Mansfield sandstone is also characterized by lateral and vertical lithologic variations and does not differ markedly in its features from Chester clastic rocks. Consequently, where the stratigraphic position of the pre-Pennsylvanian unconformity places the Mansfield on a Chester clastic formation, the stratigrapher is faced with the perplexing problem of differentiating Lower Pennsylvanian and Chester rocks; according to present knowledge, this cannot be done with certainty. A number of criteria, some of which will be mentioned later, will generally suggest either a Mansfield or Chester identification for the rocks in question.

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Although the regional aspects of the pre-Pennsylvanian unconformity are well known, the literature contains few, if any, detailed descriptions of accurately located sections where the unconformity can be measured and studied. The purpose of this paper is to describe a section in which the unconformity can be demonstrated locally rather than regionally. The section under consideration is located in the NW¼ NW¼ sec. 28, T. 2 N., R. 2 W., 1.5 miles west of the village of Prospect and 0.5 mile south of U. S. Highway 150, in western Orange County (Fig. 1).

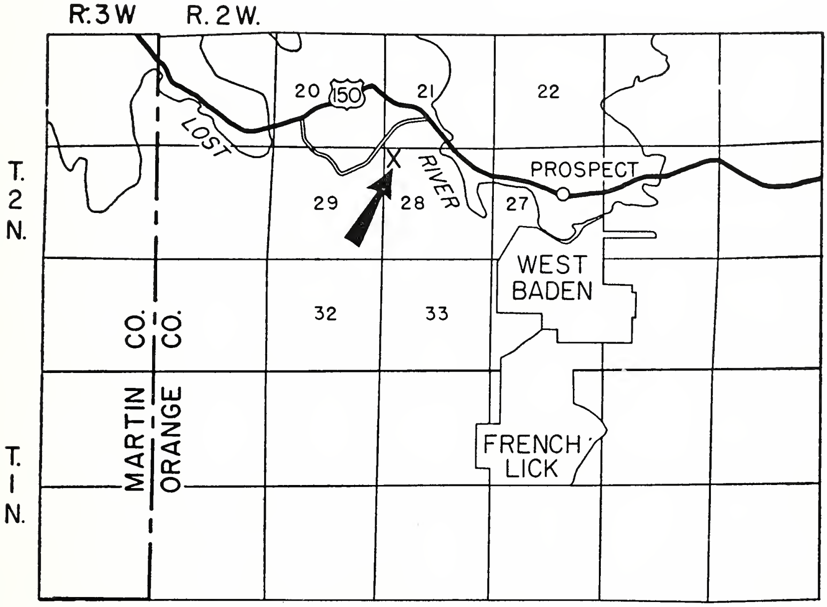

Fig. 1. Map showing location of described section.

In this section, the lowest exposed formation is the Beaver Bend (lower Chester) limestone, which roofs a spring near the north end of the exposure. The Beaver Bend is here a light- to buff-gray, fine- to medium-grained, crystalline limestone that is oolitic in the upper beds and locally stylolitic. The exposed part of the formation measures 17.1 feet in thickness, and individual beds range from 0.1 foot to 2.0 feet thick. *Linoproductus ovatus* (Hall) is the most abundant fossil in this exposure; other identified fossils are *Productus fasiculatus* McChesney, *Spirifer leidyi* Norwood and Pratten, *Orthonychia* sp., compositoid brachiopods, and a few small crinoid stems.

Immediately above the Beaver Bend is light-gray, rust-spotted, fine- to medium-grained sandstone that has irregular beds averaging 0.3 foot thick, except in the basal 1.0 foot where all beds are less than 1.0 inch in thickness. Some beds in this interval are orange-brown and highly ferruginous. This 8.6-foot nonfossiliferous unit is assigned to the Mansfield but, on the basis of its thin-beddedness, the clastic rocks in this unit may be the lower part of the Sample sandstone of lower Chester age.

The next overlying unit, 37.7 feet in thickness, is assigned to the Mansfield sandstone of Lower Pennsylvanian age. This unit consists of light-gray and rust-colored, fine- to medium-grained, ferruginous nonfossiliferous sandstone that is conspicuously cross-bedded and has a pitted weather surface (Fig. 2); this sandstone is essentially massive and forms an impressive cliff that is several hundred feet in length. The prominent crossbeds in the photograph strike N. 45 degrees W. and dip 23 degrees SW. Elsewhere on the outcrop, the crossbedding is randomly oriented, but the high-angled dips are dominantly south and southwest. The high angle of the crossbeds and their irregular orientation strongly suggest that this sandstone was deposited in a fluviatile environment.

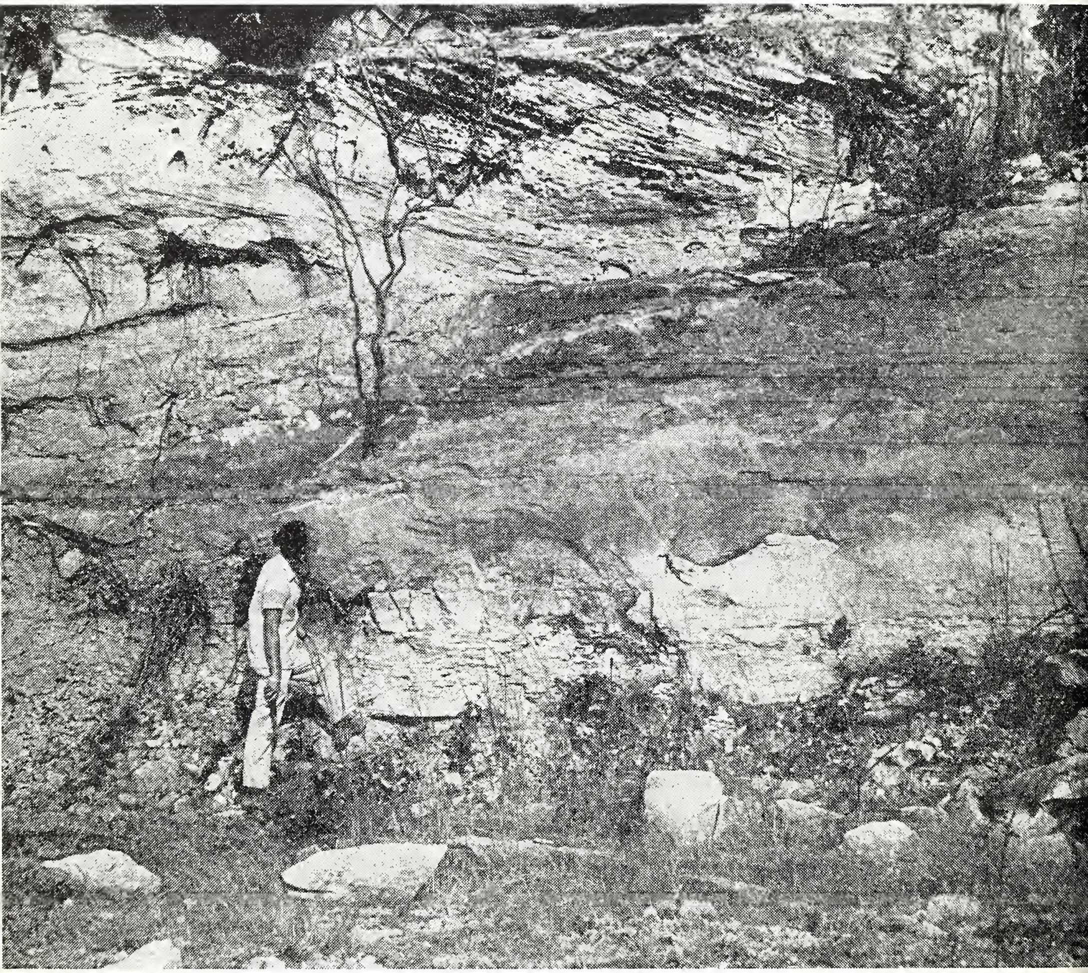

Fig. 2. Crossbedding in Mansfield sandstone in Orange County.

A 44.5-foot covered interval overlies the prominent cliff of the underlying unit. The terrane of this covered interval, however, is strewn with many large sandstone blocks that have the same lithology as the sandstone in the underlying, cliff-forming unit. This covered interval is followed by a 17-foot section of medium-gray, fine- to medium-grained, crystalline Beech Creek limestone that is readily identified by the large (somewhat over 0.5 inch in diameter) crinoid stems that it contains. The exposure of Beech Creek is located about 300 feet southeast of the massive sandstone cliff.

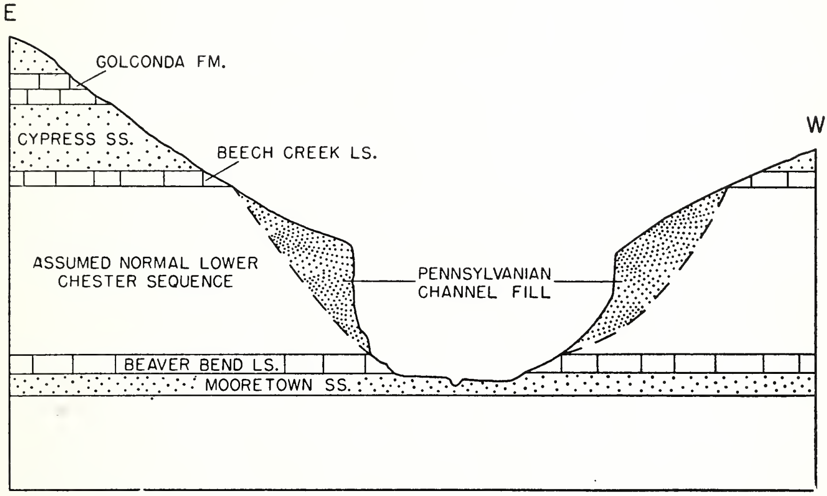

Fig. 3. Diagrammatic interpretation of a Pennsylvanian channel fill in Orange County.

The remainder of the hill is largely covered. A few poor exposures of the Cypress sandstone may be observed, however, and these are overlain by poorly exposed, cherty limestone of the Golconda formation. The terrane above the Golconda is covered by blocks of sandstone float but whether these blocks have come from the Hardinsburg sandstone of middle Chester age or from the Mansfield cannot be determined.

The normal stratigraphic sequence, in ascending order, between Beaver Bend and Beech Creek limestones is as follows: 16 to 35 feet of thin- to massive-bedded Sample sandstone; a 3- to 6-foot thickness of gray, massive, crystalline Reelsville limestone that typically weathers to a distinctive rust color; and about 40 feet of Elwren sandstone that normally contains, in part, red and green, thin-bedded shale.

In this section, however, a 91-foot stratigraphic interval that is composed entirely of clastic rocks, mainly sandstone, intervenes between the Beaver Bend and Beech Creek limestones. The most prominent unit in this interval is the 37.7-foot cliff of massive sandstone whose base is 8.6 feet above the upper surface of the Beaver Bend limestone. Thus, the normal, expectable horizon of the Reelsville limestone, as indicated by the thickness of the underlying Sample sandstone, here falls within the upper and lower boundaries of the cliff. Furthermore, the massive appearance of this cliff-forming sandstone and particularly the prominent, high-angled crossbedding is more suggestive of the Mansfield than a Chester sandstone.

For the above reasons, the authors interpret the sandstone between the Beaver Bend and Beech Creek limestones in this section as a Lower Pennsylvanian channel fill that was deposited in a steep-sided pre-Pennsylvanian valley which was carved into a Mississippian terrane (Fig. 3). In making this interpretation, the authors realize that the Reelsville limestone may be locally absent (2, p. 14, 48); the authors have observed this limestone, however, in the NW¼ sec. 18, T. 2 N., R. 2 W., about 2 miles northwest of the section under consideration. This interpretation is logical and is in accord with present knowledge of the irregular topography that the pre-Pennsylvanian erosional surface displays. Future studies of the Mansfield sandstone and Chester clastic rocks may reveal criteria by which they can be indisputably differentiated in the field. If such criteria should prove that the interpretation of the authors is incorrect, then the Reelsville limestone is most assuredly missing in the immediate vicinity of this section. If the interpretation herein placed on this section is correct, a drill hole located on or slightly above the Beech Creek limestone should pass through a normal lower Chester sequence in which the Reelsville limestone would be encountered.

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A Pleistocene Section Near Greencastle, Indiana

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General—Stripping at a limestone quarry in the NW¼ NW¼ sec. 29, T. 14 N., R. 4 W., 1½ miles southwest of Greencastle in Putnam County has revealed an unusual Pleistocene section for the area. The location is near the boundary of the Wisconsin drift where it thins out over Illinoian drift. The two drift sheets are here separated by a silt (loess) interval, averaging several feet thick. In the upper part of the silt interval are small gastropods and wood fragments.

Silt (loess)—Between the two tills is 5 feet of buff to gray silt. The upper two feet is slightly oxidized and slightly calcareous with scattered woody fragments and small gastropod shells near the top. A few small frosted quartz sand grains are scattered in the silt. The lower three feet is gray, noncalcareous, tightly compacted silt. The sand content is higher than in the silt above. The lower contact of the silt with the Illinoian till is well defined by the oxidized gumbotil line. The upper contact between the silt and the Wisconsin till where iron-stained banding is prominent, is less regular and somewhat undulating.

Buried Fossil Wood—In the upper 12 inches of the silt are scattered accumulations of wood and peaty fragments. The wood consists of logs, branches, and roots? up to 6 inches in diameter. A few leaf impressions are in the peaty silt. Some of the specimens are conifers, probably species of spruce. Sections of the wood viewed under the microscope reveal tracheids common to conifers. Though the wood is confined to a definite horizon, no particular orientation of the logs is apparent. Dating by the radiocarbon method has established the age of the wood as 19,500 ± 800 years (1).

Fossil Molluscs—The fossil wood layer near the top of the loess carries a land gastropod fauna. The fossil gastropods are localized and not plentiful, but the fragile white shells can easily be seen with the naked eye. A few have been reworked in the lower several inches of the Wisconsin till, but the main layer is closely associated with the wood zone. Hardy species that can withstand considerable change and variation predominate in the gastropod fauna. One of the most common is *Hendersonia*, a gastropod that normally lives in a climate similar to or colder than that of west-central Indiana (2).

The following species are present:

Cionella lubrica
Discus shimeki
Hendersonia occulta
Stenotrema leai
Succinia avara
Succinea groversoni

Correlation—Below the silt are several feet of iron-stained blocky leached gumbotil and till. Locally calcium carbonate concretions are near the base of the till which rests on the Aux Vases? shale at the top of the quarry rock. Small pebbles of quartz, chert, and igneous rocks are found sparingly in the lowest till. There is some doubt as to the age of the gumbotil, but it is here interpreted as a weathered soil zone at the top of the Illinoian till. The age of the wood (19,500 ± 800 years) in the silt above the gumbotil indicates that the silt interval is Iowan or Late Farmdale age. Farmdale equivalents are not surely recognized in this section, for Farmdale wood samples are dated near 24,000 years old (3).

PLEISTOCENE SECTION, 1½ miles southwest of Greencastle, Indiana, near east wall of a limestone quarry, NW¼ NW¼ sec. 29, T. 14N., R. 4 W., Putnam County.

Wisconsin Stage	Ft.	In.
14. Soil, stripped	2	
13. Till, buff, leached; rocks sparse in upper part; iron-stained at base, leached	5	2
12. Till, buff, slightly calcareous	1	8
11. Till, buff, very calcareous	1	7
10. Till, gray, moderately stony, calcareous; a few small gastropods at base	3	4
9. Silt (loess), gray with iron-stained laminae slightly calcareous; scattered small gastropods which include *Succinea avara*, *Hendersonia occulta*	0	9
8. Silt (loess), gray to dark gray, wood of conifers with limbs and roots up to 6 inches in diameter; a few small scattered gastropods, slightly carcareous	1	0
7. Silt (loess), gray, small leaves and twigs, noncalcareous	0	3
6. Silt (loess), dark gray, wood fragments up to 4 inches in diameter, some near charcoal, noncalcareous	0	6
5. Silt (loess), gray, dense	1	0
4. Silt, some clay and sand with a few small pebbles, gray above becoming buff downward, a few carbon specks near top, noncalcareous	1	0
Illinoian Stage		
3. Weathered soil (gumbotil), blocky, leached, iron-stained	3	0
2. Calcareous concretion line	0	3
Mississippian Period		
Chester Series		
Aux Vases? formation		
1. Shale, gray with blue-green cast, thin bedded, noncalcareous, overlying cavernous Ste. Genevieve limestone	7	0
Top of quarry		

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Three Pleistocene Terrace Levels Near Terre Haute, Indiana[1]

CHARLES E. WIER and S. A. FRIEDMAN, Indiana Geological Survey

During the summers of 1953 and 1954 the authors were engaged in mapping five 7½-minute quadrangles along the Wabash River in the northern half of Vigo County and the southern half of Parke and Vermillion Counties. Some difficulty was experienced in trying to delimit the boundaries of two sand and gravel terraces. This difficulty led the authors to make a more detailed investigation of the area.

These sand and gravel terraces are of Wisconsin age. They were noted at least 85 years ago by Bradley (3) while he was making a study of the geology of Vermillion County. Although he did not have time to study the terraces, he suggested that they resulted from action of local tributaries of the Wabash River. Many later workers, namely Cox (4), Scovell (9), Ashley (1), and Leverett (8) observed and discussed these terraces. Most workers considered them to be one unit. Dryer (5) described the terraces as to size and location; he stated that they extend from Montezuma to Terre Haute and rise to two or three steps from 20 to 80 feet above the floodplain of the Wabash River.

Fidlar (6, fig. 1) recognized two terraces in the vicinity of Vincennes and named them according to their origin. The uppermost terrace level was formed during Wisconsin time when the ice advanced to its southernmost extent. This limit of ice advance is marked by the Shelbyville moraine, which extends eastward across the Wabash Valley in the northern part of Vigo County. During the time that this moraine was formed tremendous volumes of water came from the melting ice and, carrying clay, sand and gravel, flowed into the drainage systems of the Wabash River. Large boulders, gravel, and sand were deposited in the valleys near the edge of the ice. The detrital material became better sorted, and grain size and quantity of material decreased downstream.

The valley fill was built to the highest level near the moraine and gradually sloped downstream. This high aggradational surface now has been greatly dissected and forms the tops of irregular patches of terrace along the Wabash River. Because of the relationship in time between the Shelbyville moraine and the upper terrace, Fidlar (6) designated it the Shelbyville terrace.

This upper level does not begin at the south edge of the Shelbyville moraine, however, but continues at about the same slope several miles northward, where it is overlapped by younger outwash. One should expect the valley fill to continue northward because torrents of water carrying a heavy load of gravel, sand, and clay continued to flow down the Wabash River and to fill the valley with outwash sand and gravel as the ice melted and the ice front receded.

The upper surface of the lower terrace was developed at the end of

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[1] This paper is presented with the permission of the State Geologist, Indiana Geological Survey.

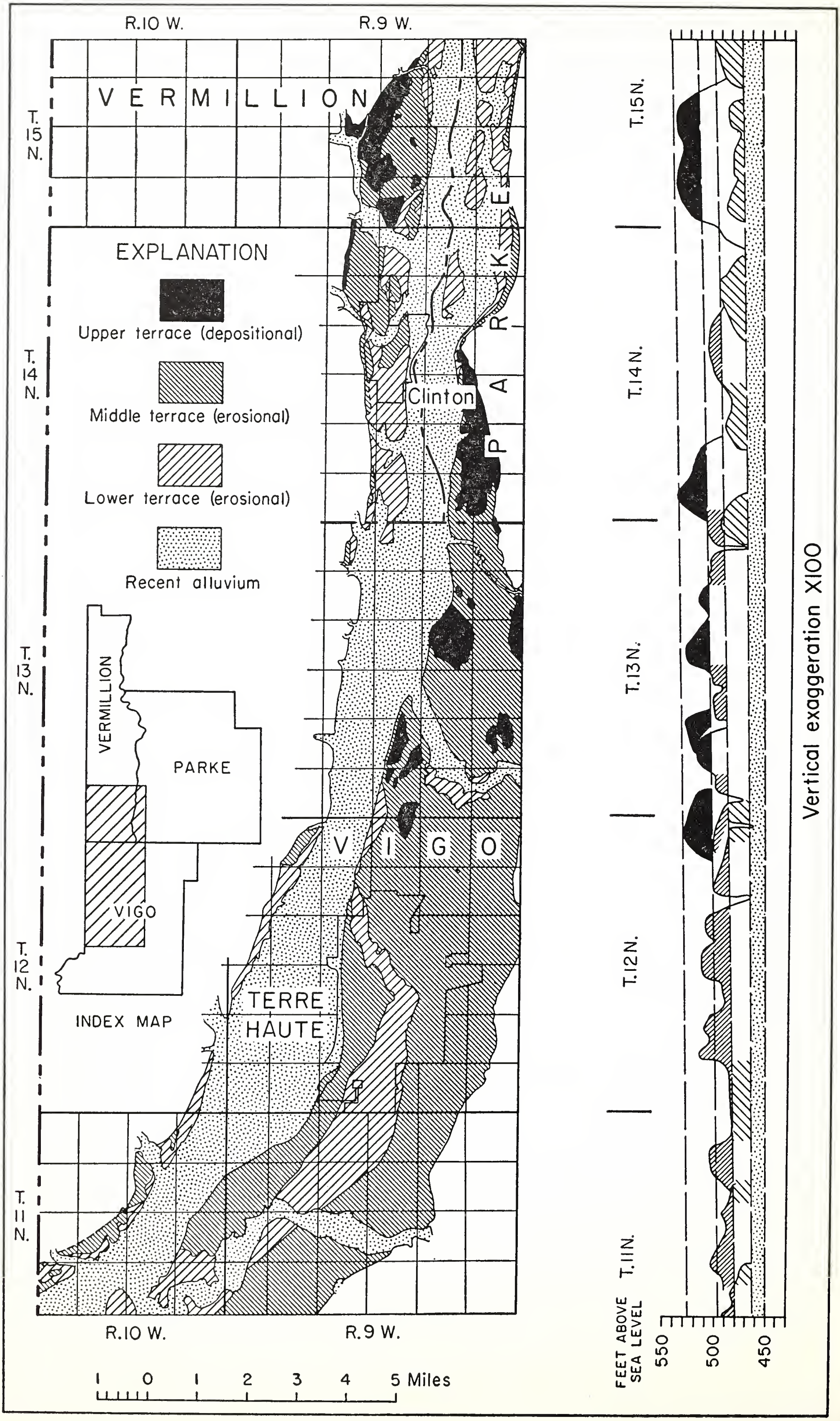

Fig. 1. Map and cross section showing terraces near Terre Haute, Indiana.

Cary time when floodwater from Lake Maumee flowed down the Wabash River. After the Erie lobe had completely withdrawn from Indiana, water was ponded in Lake Maumee northeast of Fort Wayne, Ind. The surface water at this place normally would have flowed northeast through Lake Erie, but this area was still covered with ice, which served as a dam. The water rose in Lake Maumee until it spilled out into the Wabash drainage.

Remnants of the beach of this lake and the spillway are still well preserved near Fort Wayne. The spillway is now occupied by the Little Wabash River. The water from Lake Maumee was relatively clear inasmuch as the clastics from the glacier already had settled out in the lake. This torrent of water eroded large amounts of sand and gravel that previously had been laid down as outwash from the glacier and it cut the river bottom to a lower level. This level of erosion forms the top of the Maumee terrace (6).

Recent studies indicate that more than two terraces are present. Certainly three terraces can be recognized in the Clinton-Terre Haute area and perhaps more could be mapped if altitudes were carefully plotted. Remnants of the upper terrace level were mapped by Fidlar (7) along the Wabash River from about 10 miles north of Terre Haute southward to about 10 miles north of Vincennes. Wayne (11) mapped a similar upper level of valley fill northward to Lafayette. Only the uppermost level of the Shelbyville terrace of Fidlar and the uppermost level of valley fill of Wayne are here mapped as the upper terrace (fig. 1).

The composite cross section shown in figure 1 extends along the river in the mapped area and includes the entire width of the valley. Representative remnants in the middle and on both sides of the river are included. A few remnants which are difficult to interpret because of a cover of hillwash or wind-blown sand were left off. Because the vertical exaggeration of the cross section is 100 times, all differences are accentuated.

The upper terrace has an altitude of 550 feet 5 miles north of Clinton and 530 feet in the north side of Terre Haute. This level also is farther south in the southern part of township 11 and the northern part of township 10 at an altitude of 505 to 510 feet. Thus the top of the upper terrace slopes southward 1.25 feet per mile.

The upper surface of the middle terrace is 20 to 25 feet below the top of the upper terrace in the mapped area. It is represented as a well-defined area just north of our map in the northern part of township 15 at an altitude of 530 feet. It occurs at an altitude of 510 feet at Clinton, 500 feet at Terre Haute, and 490 feet at the south end of the mapped area. This middle terrace is not as distinct as either the upper or lower one and, in some localities, appears to be a broad slope between the two, but distinctly separated from them. In townships 11 and 12 the upper surface of the middle terrace is not well marked. The middle terrace may rise locally as much as 10 feet higher than the interpolated slope (fig. 1) would allow. Part of this discrepancy may be due to wind-blown sand piled on top of the terrace, but sand is not thick enough to account for all of the difference. Perhaps this anomaly represents incomplete cutting down of the upper terrace or possibly an intermediate level between the upper and middle terraces.

The top of the lower terrace is sharply defined. It lies approximately 40 feet below the upper terrace and slopes southward about the same amount as the upper terrace. The lower terrace is 510 feet in altitude in the northern part of the mapped area, 500 feet near Clinton, 490 feet at Terre Haute, and 470 feet in the southern part of the mapped area.

Three small island terraces, each less than 1 mile long, are shown in township 15 north. These island terraces are 10 to 15 feet below the projected level of the lower terrace as shown in the cross section; they probably resulted from partial erosion of the lower terrace. The area mapped as lower terrace just north of Terre Haute in section 35 probably owes its origin to erosion by flood waters from Otter Creek rather than from Lake Maumee.

The upper terrace is probably the uppermost level of valley fill that was deposited during Wisconsin time when the ice sheet reached its maximum southern extent and then retreated northward. In Wabash County (13) the upper level of valley fill is younger; it was deposited during Cary time and is called the Mississinewa terrace. During the time Cary sand and gravel were deposited in the upper reaches of the Wabash River, some sand and gravel were being eroded in the lower part of the Wabash. The erosion which produced the middle terrace may be accounted for by water which flowed for a long period of time down the Wabash River after the time of maximum deposition of sand and gravel and before the Maumee overflow.

Withdrawal of the ice sheet in Indiana from the Shelbyville moraine was not continuous and uniform (12) but consisted of two distinct fluctuations. After the ice receded northward it readvanced, although not as far southward, to form the Bloomington moraine. Again the ice receded and again advanced a shorter distance, deposited the Packerton and Mississinewa moraines, and receded. Other fluctuations of the ice must have occurred between these known ones.

The time which elapsed between the deposition of the Shelbyville moraine and the spilling of Maumee waters down the Wabash River must have been more than 5,000 years. Recent radiocarbon dating (2) indicates a date of 19,500 ± 800 years for wood found at the base of Wisconsin till near Greencastle. Suess (10) gives a date of 13,020 ± 400 years for a material deposited in Late Cary time in Steuben County and approximately 11,400 years for a deposit from the Two Creeks interval from Manitowoc County, Wisconsin. The overflow from Lake Maumee down the Wabash River must have occurred between these two dates. During nearly all of this time glacial meltwater in varying amounts flowed down the middle and lower Wabash Valley.

The lower terrace was eroded to its present level by floodwaters from Lake Maumee. The present floodplain and channel were cut down after the water from Lake Maumee no longer flowed down the Wabash River but flowed through an outlet into Grand River and across southern Michigan. Since that time the ice sheet has been absent in Indiana, and normal runoff waters have eroded the floodplain to its present level.

In summary, at least four distinct topographic levels are represented by straths of outwash sand and gravel in the Clinton-Terre Haute area. The upper terrace level is the upper level of valley fill. The middle terrace is a level of erosion that had been reached before the water from Lake Maumee spilled down the Wabash River Valley. The lower terrace is the bottom of the valley after erosion by Lake Maumee water. The present floodplain resulted from erosion since the time that Lake Maumee water ceased to flow down the Wabash River. Cutting down to the middle terrace level took 5,000 to 8,000 years. Cutting down to the top of the lower terrace probably required a few hundred years, and cutting down to the present floodplain level required another 10,000 to 13,000 years.

When terrace remnants are plotted on a cross section of the entire Wabash Valley, a series of overlapping slopes should become apparent. Each slope represents a fluctuation of the ice front and consists of a depositional part at the upper end and an erosional one at the lower end.

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Indiana's Boundaries and Size

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The location of Indiana's boundaries determine the State's shape and size and illustrate the significance of geographic influences.

Indiana's southern boundary is the northern boundary of Kentucky, an older State. Kentucky extends to the north bank of the Ohio River because when it was created in 1792, the Ohio River was so significant as the major transportation route that Indians were excluded from its use.

As the Ohio River is constantly changing its course, by erosion of its banks and shifting, Indiana's southern boundary shifted constantly as long as it was defined as the north bank of the Ohio River. The U. S. Supreme Court later ruled, however, that Indiana's boundary was where the north bank was located when Indiana was admitted as a State, in 1816. As a result of a considerable change in the course of the Ohio River just southeast of Evansville, a few hundred acres of Kentucky is now north of the Ohio River. This tract, over which Indiana has no legal control, and which is little controlled by Kentucky, is the site of a commercial race track and considerable activity which is illegal in Indiana.

The eastern boundary of Indiana is the western boundary of Ohio, which was admitted as a State in 1803. Its location was strongly influenced by the course of the Ohio River; the boundary extends northward from approximately the northernmost point of Kentucky. From that point, the Ohio river turns almost due south for 30 miles. Ohio's western boundary was logically located west of Cincinnati, already a leading Ohio city. It could not have been located more than a few miles west of Cincinnati, however, without including an irregularly shaped, almost detached, southern area resulting from the sharp southward bend of the river already mentioned. To include the mouth of the Miami River, an Ohio stream, in Ohio instead of in Indiana Territory, the boundary was located a couple of miles west of "the top of the big bend" of the river.

The northern boundary first proposed for Indiana was a western prolongation of Ohio's northern boundary. If this parallel of latitude had been used as the boundary, the only natural harbor on the southern end of Lake Michigan, that of Michigan City, would not have been in Indiana. As that harbor was then considered as the "natural outlet" for much of northern Indiana, the State boundary was set at the parallel which is about four miles north of the Ohio boundary.

The western boundary of Indiana prescribed in the Enabling Act was the middle of the Wabash River from its mouth northward to where it last crosses the meridian which passes through a specified point in Vincennes, and "thence along that meridian northward to the end of Lake Michigan." The best map then available indicated that the end of Lake Michigan was almost due north of Vincennes. The Enabling Act specified also, however, that the boundary was to be a line marked with appropriate markers by a pair of surveyors appointed by the governments of Indiana and Illinois. When these surveyors followed the prescribed meridian northward they found that instead of reaching the south end of Lake Michigan, it reached the lake near the mouth of the Chicago River, bordering the present "loop," or central part of Chicago. Obviously they could not follow the directives of the Enabling Act, "to follow the meridian to the south end of Lake Michigan." They decided privately on a compromise. Starting again on the north bank of the Wabash River near Terre Haute, where the Vincennes meridian leaves the river, they made a new survey departing from true north a little each length of their surveyor's chain, a link of the chain. This brought them to Lake Michigan approximately halfway between the south end of the Lake and the point where the meridian of Vincennes reaches it. This placed all of Chicago in Illinois. The requisite stone boundary markers were erected, and the boundary was established. They did not report that they had compromised because it was impossible to carry out the directives of the Enabling Act. Not until a more accurate map of Lake Michigan and the general area was published years later did "the public" become aware of the fact that Indiana once had a shadowy claim to much of Chicago. Protests did not bear fruit partly because the Enabling Act had also declared that the boundary was to extend to the south end of Lake Michigan. If that directive had been followed, Illinois would have included what is now Gary. Moreover, the Act prescribed that the boundary was that appropriately marked by the joint survey. This boundary had been mutually accepted for years. Undisputed possession for many years establishes a valid claim to real estate, according to the well-recognized "common law."

Let us now consider the size of Indiana, on outgrowth of its boundaries.

Although Indiana is only about half the size of the average State today, it was not small in comparison with most of the States already in existence at the time it was established in 1816. Of the first 13 States, the average size was less than half that of Indiana; only five (New York, Pennsylvania, Virginia, North Carolina, and Georgia) were larger, and they were little larger. Of the five others admitted before Indiana was, Vermont is smaller and Kentucky, Tennessee, Louisiana, and Ohio a little larger than Indiana. Indiana is thirty-seventh in size among the 48 States, Kentucky is thirty-sixth, and Ohio is thirty-fourth.

However, since Indiana was admitted, only one smaller State has been created, West Virginia. It is 40th in area.

The fact that Indiana's size, according to the boundaries suggested for it by certain natural features to the west and north was "about the right size" in the opinion of Congress in 1815, facilitated the adoption of those boundaries. An official (inaccurate) map of that time depicted the northern boundary of Ohio and of the territory of Indiana as a parallel of latitude extending from the western end of Lake Erie to the southwest tip of Lake Michigan. Indiana's western boundary extended therefrom south along the Vincennes meridian. The northern boundary of Ohio soon was shifted, however, northward a little to include in Ohio all of Toledo, which is at the end of Lake Erie. That shift set the precedent that facilitated a further shift northward of Indiana's preliminary boundary to include the harbor of Michigan City. There was no local demand for a further northward shift. As to its western boundary, there was no local sentiment in favor of placing the boundary west of the lower course of the Wabash River. Few people lived then near the Wabash River in what is now Illinois. The nearest sizable river west of the lower Wabash is the Kaskaskia. The few people living then between the Wabash and Kaskaskia rivers were not interested in being included in Indiana; their outlook was southward, towards the Mississippi River.

The fact that Indiana is a small State as compared with most other States obscures its richness when comparisons are made which involve total area as for example, agricultural production. Illinois, Michigan, Iowa, and Wisconsin each are about 50 per cent larger than Indiana, and Ohio and Kentucky each are about a tenth larger; Missouri is about twice as large, and Kansas, Minnesota, Nebraska, North and South Dakota each about two and a half times as large. Montana and California are 4 to 4½ times, and Texas, 7½ times as large. When comparison is made per average square mile, however, it is seen that Indiana surpasses many states which produce far larger totals of crops and farm animals.

Although Indiana is a relatively small State, it is larger than several well-known countries. For example, it is more than twice as large as Denmark, Switzerland, Belgium, or Netherlands.

Indiana's area is about 36,300 square miles; its average width is almost 150 miles, and average length about 250 miles. Its land area is about 21,000,000 acres. Only the marginal waters of Lake Michigan (228 square miles) are counted as part of Indiana. Indiana's water-covered area is increasing progressively by the construction of artificial lakes and ponds, the largest two of which (1954) are larger than its largest natural lake.

Some Problems of Irrigation in Indiana

THEODORE M. KINGSBURY, Indiana Department of Conservation

Within the last few years, particularly the last two, crop irrigation has been given a great deal of attention in Indiana. According to estimates made in the spring of 1953 by county agricultural extension agents, about 300 Indiana farmers were using irrigation on more than 15,000 acres. Various reports received during the past summer indicate that the acreage had more than doubled.

There is ample evidence to indicate that proper irrigation of farm crops will materially increase yields. Irrigated pastures, for example, have more than doubled their livestock carrying capacity. Non-irrigated fields of corn have produced 40 to 45 bushels per acre whereas other fields, with similar culture but with irrigation, produced nearly three times that amount.

The prolonged droughts of the past two growing seasons have undoubtedly stimulated the stepped-up interest in irrigation, but it must be recognized that irrigation is being considered more and more on Indiana farms as a means of increasing profits in normal as well as in dry years.

Irrigation, however, is not a cure-all. It requires good farm management and the solution of some important problems to make it succeed. It will not, for example, make up for any lack of fertility, inferiority in quality of seed, or the neglect of insect control. Also water that is applied to stimulate crop growth will likewise stimulate weed growth. There are problems in the selection of proper types and sizes of pumps, and the power units to operate them; the equipment necessary to distribute the water uniformly over the fields with the minimum of labor and in sufficient amounts; the spacing of the sprinklers and the lateral lines; and in the timing, frequency of application and the amount of water used. But the most important consideration of all is the available water supply. An adequate water supply is prerequisite.

The quantities of water required for irrigation are much more than many people realize. To cover one acre of land with one inch of water requires 27,154 gallons. According to reports issued by Purdue University Agricultural Extension Service, from three to ten inches applications may be needed annually in Indiana, depending on the crop being irrigated, the type of soil, and weather conditions. A well producing at the rate of five or six gallons a minute and pumping continuously day and night for a month would supply enough water to irrigate only one acre of land during a relatively dry season.

The Indiana Department of Conservation is receiving more and more inquiries in regard to pumping water from lakes, rivers and streams for irrigation. The law is not too clear regarding water rights and new problems are sure to arise as to its rightful use.

Under Chapters 181 and 301 of the Acts of 1947 the Department has jurisdiction over the public fresh water lakes of the State and before anyone can change the shore or bed of a lake or lower the water level, he must secure the written approval of the Department. Under this authority the Division of Water Resources is requiring that individuals or others wishing to pump water from a public fresh water lake first secure a permit to do so.

Under Chapter 60 of the Acts of 1919 the Department has jurisdiction over the navigable streams of the State. At the present time the Wabash River and White River to the junction of the East and West Forks, and the West Fork as far north as Marion County are generally considered as the only navigable streams in the State. However, some years ago the State Legislature declared a number of other streams as navigable or as public highways, and the Division of Water Resources is now compiling a map showing these streams which were declared navigable by legislative action.

Under authority of the law relating to navigable streams we are requiring a permit to remove water from the Wabash and White River, and when information is officially released regarding the navigability of other streams a permit will also be required to remove water from them.

A farmer may install an irrigation system and withdraw water from a non-navigable stream. As a riparian owner he can do this with certain limitations, since the above mentioned law does not apply to streams of this kind. There may be plenty of water to meet his needs. But what is the solution to the problem that arises when his neighbor also installs a similar system and begins to draw water from the same stream. Then another land owner upstream, seeing the benefits of the others, invests in the same sort of equipment and takes water from the stream thus depriving the others. Similar problems may arise from the use of ground water. One well in a given area may yield enough water for irrigation purposes, but when other wells are drilled and irrigation pumps begin to operate, the time may come when there will not be enough water to meet the needs of all.

Other problems are created when conditions such as these develop. The Federal Government has recently enacted a law under which individuals can borrow money to drill wells and build ponds under certain limitations for various uses, including irrigation. Since the funds are loaned they must be returned, and if other irrigation projects are started which would reduce or deprive the original borrower of his supply it might put him in a position where he would not be able to repay the loan. The agency administering this law has already asked if such loans are good risks.

These points serve to illustrate that no matter how good the results are that may be obtained from irrigation it is necessary to see that an adequate water supply is available and that its use will not interfere with others who may have a riparian right to it. They also show that before irrigation can go very far in this State, that additional laws are necessary to regulate and control the use of both surface and ground water.

Atomic Energy and the Ohio River

THOMAS FRANK BARTON, Indiana University

Industrial growth in Indiana and other parts of the Ohio River watershed has been and continues to be stimulated by the development of atomic energy. Within a 250-mile radius of Cincinnati alone is almost 70 per cent of the Atomic Energy Commission's planned development east of the Mississippi River. Government-owned plants at the following towns and cities will represent an investment of over 4 billion dollars[1]: Paducah, Kentucky; Portsmouth, Miamisburg, Fernald, Luckey and Cleveland, Ohio; Oak Ridge, Tennessee; Pittsburgh, Pennsylvania; and Dana, Indiana.

Gaseous Diffusion Plant Sites

Of the three plant sites the Semiannual Reports published by the Atomic Energy Commission give the criteria used in selecting the second and third sites at Paducah and Portsmouth but not of the first at Oak Ridge, Tennessee.

Paducah plant site. The Paducah plant is located on a 5,000-acre tract including the 1,400 acres formerly occupied by the Kentucky Ordnance Works. This tract is 16 miles west of the city. Primary factors in selecting this site were[2]: 1. "for reasons of speed and economy the search was confined to tracts owned wholly or partially by the Government"; 2. availability of fuel and water for large new power plants; 3. availability of substantial amounts of power during construction of new power plants and 4. sufficiently level land for large scale construction. Some available government-owned land was too rough. The land of the Kentucky Ordnance Works was not only sufficiently level but the government owned 1,400 acres. Moreover, it had retained legal right to another 1,000 acres when operation was temporarily abandoned and some of the land reverted to private use after the Second World War.

However more important than legal right to the tract was its juxtaposition to the Ohio River—in volume the second largest river in the United States. Here was water in abundance—enough for the present and foreseeable future. For steam-electric power development the Ohio provides the greatest potential water supply of any river in the United States. Only the Mississippi below Cairo has a greater volume but this river does not have potential dam sites where water can be stored in huge reservoirs for use during the summer and fall or other low water periods.

Furthermore the navigable Ohio and its tributaries provide an artery for cheap barge transportation between the two largest and richest coal fields in the United States and the proposed steam-electric plants now under construction along its banks.

In addition, the great TVA power system is conveniently located to supply over half of the energy needed when this second diffusion plant at Paducah is in full operation.

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[1] Personal letter from R. W. Cook, Assistant General Manager for Manufacturing, United States Atomic Energy Commission, Washington 25, D. C. June 1, 1954.

[2] *Semiannual Report of the Atomic Energy Commission.* United States Government Printing Office, Washington, D. C. January, 1951, pp. 4 and 5.

Portsmouth plant site. In a news release of the United States Atomic Energy Commission dated August 13, 1952, the second paragraph reads as follows:

> "Funds for the project were made available for Public Law No. 547 signed by the President on July 15. However, locations had been studied for many months. The potential availability of power at reasonable cost in quantities needed for operation of the plant and the availability of water were important factors in selecting the site."

Plant sites on the Ohio watershed. The location of these three plants on the Ohio watershed becomes more significant when we recognize that each one was built in succession after the former proved the wisdom of its location. The choice of the Paducah and Portsmouth sites was made after an announced program for the dispersement of atomic energy plants throughout the United States. It was also made after the building of the major facilities for the production of fissionable materials had centered[3] at the Hanford Plutonium Works located on the Columbia River in Washington just above the junction of the Yakima and Columbia rivers. Just like in 1948, when the following statement was published, the Commission today attempts to disperse plants:

> "Today, at the close of 1948, fissionable-materials production extends into at least 15 states of the Nation from coast to coast. It is carried on in 30 separate plants at 25 locations. . . ." [4]

But factors of water supply, electric energy, cheap water transportation and terrain cannot be ignored.

These three plants costing $3,727,500,000 represent approximately 90 per cent of the government's investment in atomic energy development in the Ohio watershed.

Steam-Electric Plants

Energy need. It is difficult for the layman to visualize the amount of energy needed to run the Oak Ridge, Paducah and Portsmouth plants at full capacity. The amount is estimated by the Commission at 47,221,346 MWH (million kilowatt hours). This is more than the total amount of electrical energy produced in France or Federated Germany (West) or Japan in 1950. It is an amount greater than the combined 1950 production of Norway, Sweden and Switzerland. In 1950, Canada's production was only 7.8 per cent greater and the United Kingdom's only 19.3 per cent greater than that needed for these three plants. Operating at full capacity they will use more energy in a year than that used in 1950 in the states of Illinois and Ohio.[5]

Sources of energy. This enormous amount of energy will be supplied from both private and public sources. Electric Energy, Inc., is building a plant at Joppa, Illinois, large enough to supply about three-eighths of the power needed for AEC's Paducah plant.[6] The cost of plant and transmission lines is estimated around 197 million dollars. The rest or five-eighths of the electric power for the Paducah plant will be supplied from the TVA's Shawnee plant.

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[3] *Fifth Semiannual Report of the Atomic Energy Commission.* United States Government Printing Office, Washington, D. C. January, 1949, p. 2.

[4] *Ibid.*

[5] Op. cit. Letter from Cook and statistical materials enclosed.

All the energy for the Portsmouth plant comes from the Ohio Valley Electric Corporation's two plants now under construction near Cheshire, Ohio, and Madison, Indiana. This corporation alone plans to spend about 371 million dollars for the two steam generating plants and transmission facilities. It is estimated that barging companies and coal suppliers will spend 44 million dollars on transport, to open new, or expand old coal fields to supply these two plants.

The Tennessee Valley Authority supplies power for the Oak Ridge plant. Information is not now available on what proportions of TVA-supplied power will come from hydro-electric and steam-electric generating capacity. Mr. R. W. Cook, Assistant General Manager for Manufacturing of the Atomic Energy Commission writes:

> "The amount of coal that will be required to provide the Commission's electric power requirements at the three gaseous diffusion plants is estimated as follows:[7]

By TVA for Oak Ridge........	5,300,000 tons annually
By TVA for Paducah.........	4,200,000 tons annually
By EEI for Paducah..........	2,500,000 tons annually
By OVEC for Portsmouth.....	6,300,000 tons annually"

Consequently over 18 million tons of coal will be required to run these three plants annually at full capacity.

According to present plans most of this coal will be transported by barge. All the six million plus tons for the OVEC will be transported in this way. The TVA Shawnee and the EE Inc. Joppa plants will receive coal both by rail and barge. Both of these plants have large modern facilities for handling water-transported coal. The cheapness of water transport plus the smaller unloading space needed to handle millions of tons of coal a year by barge favor this type of transportation.

To understand what this potential increase in barge transportation will mean in stimulating business on and along the river we should recall that the greatest coal tonnage hauled on the Ohio in any one year was a little over 31.7 million tons in 1953.

Other Government-Owned Plants

Besides the plants at Oak Ridge, Paducah and Portsmouth, the government owns six additional ones which represent an investment of 283 million dollars.

Of these six the two most costly are at Dana, Indiana, and Fernald, Ohio. Material produced at the "atomic energy facility" near Dana is of vital importance to the operating schedules of the Commission's billion-dollar Savannah River Plant in South Carolina.[9]

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[6] Op. cit. Letter from Cook and statistical materials enclosed.

[7] *Ibid.*

In Fernald, Ohio, is located a complete integrated Feed Materials Production Center. Fernald is 19 miles northwest of Cincinnati. Here virgin uranium ores and concentrates are received. These raw materials are processed through a refinery, metal plant, rolling mill and fabricating plant to produce fuel elements for the nuclear reactors at Hanford on the Columbia and the Savannah rivers.[10]

From the standpoint of investment (in this group of six small plants) the two medium sized installations are at Miamisburg, Ohio, and Pittsburgh, Pennsylvania. In Miamisburg the Mound Laboratory is a research center specializing primarily in the fields of biology and medicines. Near Pittsburgh the Bettis Plant is a reactor development center.

The two smallest plants from the standpoint of money invested are at Luckey and Cleveland, Ohio. At Luckey, "the Brush Beryllium Company operates a plant for the production of beryllium, a material utilized in the construction of nuclear reactors. At Cleveland is a uranium feed material plant presently maintained at standby capacity. Materials formerly produced at Cleveland are now made at Oak Ridge, Tennessee, and at Fernald, Ohio."[11]

In summary, the locations of the government-owned installations on the Ohio River watershed and the approximate plant and equipment cost of each upon completion of presently authorized construction is as follows:[12]

Oak Ridge, Tennessee	1,700,000,000
Portsmouth, Ohio	1,152,500,000
Paducah, Kentucky	875,000,000*
Dana, Indiana	102,000,000
Fernald, Ohio	100,000,000*
Miamisburg, Ohio	40,000,000
Pittsburgh, Pennsylvania	37,000,000
Luckey, Ohio	2,300,000
Cleveland, Ohio	2,000,000
Total	4,010,800,000

* On October 12, 1954, The Courier-Journal Washington Bureau reported that an additional seven million dollars had been authorized for expansion of the facilities at the Paducah plant and an estimated 20.1 million expansion is to be made at the Feed Material Production Center at Fernald, Ohio.

The Shippingport Plant

"On October 22, 1953, the Atomic Energy Commission announced . . . that it had embarked on a project to construct a full-scale power reactor to produce a minimum of 60,000 KW of electrical energy and invited participation from private industry."[13] In the same announcement the Commission disclosed it was considering the possibility of locating this first reactor at or near one of the gaseous diffusion plants. According to the Atomic Energy Commission the following criteria would influence the selection of a site (numbering is by the author and does not indicate priority of criteria):[14]

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[9] Atomic Energy Commission Newspaper Release 7:00 a. m. Thursday, January 17, 1952.

[10] Personal letter from R. W. Cook, Assistant General Manager for Manufacturing, United States Atomic Energy Commission, Washington, D. C. August 4, 1954.

[11] *Ibid.*

[12] Op. cit. Personal letter from Cook dated June 1, 1954.

1. "In addition to normal criteria for selecting a satisfactory low cost site for any large industrial plant, the selected reactor design will require a location with an adequate supply of suitable condensate cooling water.
2. "Although the reactor is of an inherently stable type it is not considered desirable to locate it immediately adjacent to large population or complex industrial areas.
3. "The site would have to be so located that intermittent power in large amounts could be sold, absorbed or otherwise disposed of.
4. ". . . that the attractiveness of proposals involving private financing for the steam and electric generating portions of the plant and for operating the plant would considerably influence the decision on the plant site."

The location of America's first commercially operated atomic power plant in Shippingport, Pennsylvania. This hamlet is located 34.0 miles below Pittsburgh on the left bank of the Ohio River. The plant site is 2.5 miles upstream of Dam 7 and 2.3 miles downstream of Montgomery Dam. The present Dam 7 will be eliminated upon completion of the New Cumberland Dam at mile 54.4 below Pittsburgh. Then the atomic power plant will be accessible to the new pool of water formed by the high permanent New Cumberland Dam.[15]

How does Shippingport measure up to the criteria announced for the selection of the site? It meets the first by being located on the Ohio where there is an adequate supply of suitable cooling water. It meets the second and third by being 34 miles from Pittsburgh, consequently it is both far enough away not to endanger this city and its factories, yet close enough so that the electricity may be marketed in the Pittsburgh area. And Shippingport was a logical choice once the Duquesne Light Company and Westinghouse made the best offer from among the private companies willing to join the government in this undertaking.

The criteria used in selecting the site for this plant again demonstrate the importance of the Ohio River in developing atomic energy.

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[13] Fact Sheet on the New Power Reactor prepared by Atomic Energy Commission.

[14] *Ibid.* p. 3.

[15] Personal letter from Colonel W. W. Wilson, Executive Officer, Corps of Engineers, Ohio River Division, October 27, 1954.

Some Consequences of Soil Erosion in an Indiana Township

JAMES E. WRATHALL, Indiana University

Within Salt Creek Township, Monroe County, south central Indiana, there is a sharp contrast in land utilization, soil erosion, and living conditions between the rugged uplands and the bottomland. In the uplands soil erosion is serious, and farming cannot support the present population. The bottomland is not seriously affected by soil erosion and the farmers are relatively prosperous.

The township lies within the unglaciated, rugged physiographic region, "the Norman Upland." This upland plain is underlain by sandstones, siltstones and shales, and has been maturely dissected into narrow tortuous ridges by many small streams. The local relief is between 200 and 300 feet. Most slopes are steep, and fairly level land is found only on the broader ridge-tops. In contrast, the floodplain of the North Fork Salt Creek provides an extensive area of level land.

The soils consist of: 1) upland residual soils developed from cherty limestone, and sandstone and shale; 2) terrace soils developed from noncalcareous sands, silts, and clays; 3) bottomland soils developed from alluvium derived from the nearby uplands.

The upland land use pattern is one of cultivated ridgetops and forested slopes. The farms are generally less than 80 acres, of which only about 10-15 acres are cultivated. Another 10-15 acres often is pasture, and the remainder, woodland. Serious soil erosion is extensive, and the agricultural returns are low. Many farmers exploit the soil and cultivate steep slopes in order to obtain a living. This, in turn, leads to more erosion and a further reduction in the value of the land. The main crops are corn, oats, soybeans, wheat, and grass, but seldom is a good rotation maintained. Pasture is usually poor and overgrazed and is eroding badly.

On the bottomland, which has slopes of 0-1%, soil erosion is chiefly rill and sheet washing, and is not serious. Over 80% of the bottomland is cultivated and corn is the most important crop, followed by soybeans. Oats and wheat cover small acreages, and grass crops are significant in the rotation. The bottomland farms are thus relatively prosperous.

The uplands contribute little to the township revenue, because of the low value of the land and property. They are a financial burden on the better farming area, because they do not contribute in proportion to the population and extent. The township receives considerable help from the State.

The general poverty of the uplands is illustrated by abandoned farms and dwellings, part-time farming, tax delinquency, low assessed valuations, and poor homes and services.

Several abandoned farms were encountered during field work, and in most cases it was apparent that severe soil erosion had caused the farmer to abandon his home.

Many of the upland farmers hold other part-time jobs. A questionnaire filled out by school children of the township showed that all of the 24 fathers reported as farmers have additional jobs. The main area of employment is in Bloomington or in the nearby stone quarries. In many cases also, the farm income is supplemented by the earnings of children.

Tax delinquency is another indication of low income, and for the period 1943 to 1953 virtually all such land was located in the uplands.

The farm homes reflect the general poverty of the upland areas. Most houses are frame structures, which are generally badly in need of repair and paint. Most farms have an unkempt appearance, with trash and equipment cluttering the same yard. The Census of Housing of 1940 shows that of the farms reporting, not a single one had running water in the unit, or an indoor toilet; eight lacked toilet facilities, and only one possessed electric lighting. Since 1940, however, electric lighting has increased notably as a result of the Rural Electrification Administration. Water supply is a problem for the upland homes, and the cistern is the most common source. The assessed value of improvements also indicates the low value of many of the buildings.

Assessment on personal property is also low, and figuring largely in this is the assessment on automobiles. Nearly all families possess an auto, because without one the family is isolated. Four small general stores are the only shopping facilities in the township, so that Bloomington is the main service center.

On the bottomland, where soil erosion is not a serious problem, fewer farmers need have other jobs. The higher standard of living is reflected in better maintained and tidier farms and buildings.

The township has financial problems resulting from soil erosion. The revenue is derived from taxes levied upon land, personal property, and from the poll tax.

Little revenue is obtained from the uplands in proportion to their area and population. Land values vary between $1 to $10 per acre, and other assessments are low.

The bottomland is assessed generally above $10 per acre; there is virtually no delinquent tax on land; and the revenue from assessed personal property is considerable.

The township expenditures are for road maintenance, public health, assistance to the orphaned and very poor, and education. Of these, education is the largest. Some consolidation of school districts has taken place, but two schools are still maintained and a third building rented just outside the township. School busses now take many children to the local schools, and also take the high school pupils to Bloomington. In 1953, the total cost of education was $40,242, of which 30% came from the township budget, and 70% from the State. This illustrates the magnitude of outside help, and the impossible task of the township ever paying its way under present conditions.

In recent years the rural non-farm population has been increasing. Several modern homes have been built along State Road 46 and nearby along adjoining side roads. The additional revenue from taxation on this property is an important new contribution to township finances, and the township could attract more of the higher income non-farm group by providing better services.

HISTORY OF SCIENCE

Chairman: M. S. Markle, Earlham College

B. E. Montgomery, Purdue University, was elected chairman for 1955

ABSTRACTS

The Influence of Salt in the Early Life of America. Charlene Rector and Floy Hurlbut, Ball State Teachers College.—Salt is essential to animals and to human beings, especially the herbiverous animals and vegetarian man.

In the beginning, the settlement of the interior of our continent was dependent upon this essential salt being carried inland from the coast. This was an expensive and time-consuming process. Discovery of salt licks helped speed the westward movement of the white man; Kentucky and southern Indiana provide excellent illustrations of this fact.

Kentucky, unoccupied by Indians, was used as a hunting ground by all surrounding tribes. The many salt licks seemed to make possible a concentration of wild game in that area. Salt licks were the stopping places on buffalo traces and early trails. They also served as foci for the congregating of wild animals, as shown by the numerous animal bones found mixed with mud and earth around the licks.

Many of the skirmishes between the early settlers and Indians were struggles for control of salt licks; and our highways which follow buffalo traces show the influence of the location of salt licks. Early settlements were located where fresh and salt springs occurred. French Lick, Indiana, is an illustration.

David Starr Jordan and John P. D. John in the Development of the Science Major in Indiana. Will E. Edington, DePauw University.—During most of the last quarter of the nineteenth century Indiana Asbury, after 1883 DePauw University, was the largest university in the State of Indiana, so far as enrollment is concerned, and DePauw and Indiana Universities set the educational pattern for the State. During the middle half of the nineteenth century the struggle for the recognition of the sciences as having equal educational value to the classics caused considerable unrest, and the denial to the students of the privilege of choosing or electing certain subjects for study led to much educational dissatisfaction. However, Indiana University gave its first Bachelor of Science degree in 1854, and Indiana Asbury followed in 1858 with a four-year scientific course of study and gave its first B.S. degree in 1861. But these degrees implied no specialization in any one science but rather the completion of a non-classical course of study. In 1879 Indiana Asbury offered a scientific course of study in which students interested in science were advised to "choose all the studies of a few departments rather than a few from all," and the only "required subjects," after the prescribed Freshman year, were three quarters of Latin in the Sophomore year, two quarters of Belles-Lettres and one quarter of Philosophy in the Junior year, and one year of Philosophy in the Senior year.

David Starr Jordan came to Indiana University in 1879 as Professor of Zoology and he was elected President of the University in 1885. A student of Agassiz and a brilliant scientist of powerful personality, he revolutionized scientific study at Indiana University. In his "The Days of a Man," he writes: "In 1886 I made some sweeping changes, doing away with the fixed curriculum and adjusting the work so that practically all the subjects hitherto taught in the University, being elementary in their nature, were relegated to the first two years. Further than this we instituted the 'major subject' system, by which each junior or third year student was required to choose a specialty or 'major,' and to work under the immediate advice of his 'major professor,' whose counsel in details he was obliged to secure." Indiana University conferred its first Master of Science degree in 1882 and its first Ph.D. degree in 1883.

The first suggestions for specialization at Indiana Asbury appear in the Catalogue for 1874-1875 where the following statement is published: "A more extended course of instruction will be afforded those desiring to make Mathematics a specialty. Such classes will be heard in extra-collegiate hours." In 1879 a system of Departmental Honors was set up requiring of the recipient of such an Honor the completion of virtually the equivalent of a "major" in mathematics, chemistry, etc.

John P. D. John came to Indiana Asbury in 1882 as Professor of Mathematics, was made Vice-President of DePauw in 1885, and President in 1889. Like Jordan, John was a scholar with broad educational perspective and forceful personality who, upon becoming President, immediately made the "major subject" philosophy the educational policy of DePauw.

It is educationally significant that both Jordan and John were active in founding the Indiana Academy of Science. Jordan was the Academy's first President and John was its third President.

A Brief History of the Development of the Natural Sciences, University of Notre Dame

Robert J. Sheehan, C.S.C., University of Notre Dame

The Academic Organization varies in different Universities (1). That which exists at Notre Dame University is composed of five undergraduate colleges, a Graduate School, and two Institutes.

The undergraduate colleges are: the College of Arts and Letters founded in 1842, the College of Science established in 1865, the College of Law was inaugurated in 1869, and the College of Engineering was founded in 1873. These units were called divisions previous to 1905, at which time they were designated as colleges. The College of Commerce was added in 1920 (2).

The Graduate School was instituted in 1918. Before that year, graduate courses were not a regular part of the curriculum of the University. The few students who pursued studies for advanced degrees did so by special arrangement and under the direction of specially assigned members of the college faculties. With the establishment of the summer session in 1918, however, the number of candidates for higher degrees increased and more definite provision for graduate work was entrusted to a committee of twelve members of the general faculty (later reduced to seven), called the Committee on Graduate Study. In 1944 this Committee was replaced by a Dean and Graduate Council (3). Rev. Philip S. Moore, C.S.C., who had been most instrumental in encouraging graduate work, was the first Dean. He held this position until 1952 when he became Vice-President in charge of Academic Affairs. Father Moore was succeeded by the present Dean, Rev. Paul E. Beichner, C.S.C. At the present time work leading to the Master's degree is offered in nineteen departments, and for the Ph.D. degree in twelve departments of the University. In 1930, 48 students were enrolled in the Graduate School and by 1954 the enrollment had increased to 391.

The Mediaeval Institute is a foundation established in 1947 by Rev. Hugh O'Donnell, C.S.C., President of the University, for the study of the thought, history and culture of the Middle Ages. The first Director, Rev. Geral D. Phelan, ably directed the Institute until he returned to his native Canada in 1952. Father Phelan was succeeded by the present Director, Canon A. L. Gabriel.

The Lobund Institute (Laboratories of Bacteriology of the University of Notre Dame) had its beginning in 1930 (4), when members of the Biology Department, under the inspiration and leadership of J. Arthur Reyniers, began the investigation of the biology of microorganisms and micrurgy. In 1937, Professor Reyniers was made Director of the Laboratories, and in 1952 this work was officially established as a separate Institute within the University.

Before the College of Science was established the various scientific subjects were taught as part of the program in Arts and Letters. In 1844, Brother Augustine, C.S.C. was appointed to teach botany and zoology. Thomas McKinnis was listed as professor of chemistry in 1852 (5). J. E.

Tallon, M. D. (6) in 1859 joined the faculty as professor of physiology, anatomy and botany. In 1863, Rev. Louis Neyran was made professor of anatomy, physiology and hygiene, but served as Chaplain in various hospitals during the Civil War and did not begin to teach until 1866. In 1863, Rev. Thomas L. Vagnier, C.S.C. was also appointed professor of botany, as well as of chemistry and physics (7).

By 1864 the success of the scientific subjects warranted a separate organization, and in that year, under the presidency of Rev. Patrick Dillon, C.S.C., the College of Science was organized as a separate unit. From this inception there was a gradual organization of departmental administration, but no official separation into departments was made until 1920.

Rev. T. L. Vagnier, C.S.C., Professor of botany, chemistry and physics, was appointed the first director of the College in 1865 and continued in this capacity until 1868. He was succeeded by Rev. C. B. Carrier, C.S.C., Professor of botany, who, aided by Rev. John A. Zahm, C.S.C., distinguished natural scientist and Dante scholar, as his assistant, ably held the position until 1874. During these years the science courses made excellent progress through the efforts of these men and those of four or five other competent professors. It was during this period that a "partial medical course" was introduced by Father Neyron.

In 1874 Father Carrier was transferred to Texas and for the next forty-four years (1874-1918) Rev. Alexander M. Kirsch, C.S.C., successful anatomist, cytologist and bacteriologist, capably directed the study of the natural sciences at Notre Dame. On April 23, 1879 (8), five years after Father Kirsch became Director of the College of Science, Notre Dame suffered a serious fire which destroyed all the buildings except the Church and the Auditorium. This loss included the library, the museum and the herbarium which contained 4,000 to 5,000 specimens (9). Father Kirsch, like other members of the University, received inspiration and courage by the words of the sixty-five-year-old founder, Father Sorin, who, after viewing the ruins of much of the labor of thirty-seven years, finished his talk to them with these words, "If it were *all* gone, I should not give up" (10).

During Father Kirsch's directorship work in various fields of the physical and biological sciences rapidly developed. Science Hall was built in 1883 to house the developing departments of biology, chemistry, mathematics and physics, and to afford space for the rapidly growing University Museum. By 1893 it was recognized that Science Hall was inadequate and a separate building for chemistry was constructed. This building was severely damaged by fire in 1916 and plans for a new and much larger Chemistry Hall were immediately started and the new building was occupied in 1918.

In 1875 Rev. John A. Zahm, C.S.C. succeeded Rev. Thomas L. Vagnier, C.S.C. as professor of physics and chemistry, and in 1891 Rev. James A. Burns, C.S.C. became professor of chemistry. Rev. Joseph McGuire, C.S.C. was added to the chemistry staff in 1898. In 1904, Rev. Julius A. Nieuwland, C.S.C. began his work at Notre Dame in botany and chemistry, in which fields he was to gain renown. He founded in 1909, at the suggestion of Dr. Edward Lee Greene, *The American Midland Naturalist*, and edited the progressive journal until 1935, when he requested Dr. Theodor Just to assume the editorship. Under Just's capable editorship the journal increased in national and international recognition. In 1944 he introduced the supplementary series, known as the American Midland Naturalist Monograph Series. Dr. John D. Mizelle, as editor, further enhanced the reputation of the journal and the Monograph Series from 1947 to the fall of 1954, when the present editor, Dr. Arthur L. Schipper, succeeded him.

Previous to 1879, the University Herbarium contained about 4,000 to 5,000 European, New Zealand and American plants. These were destroyed by the fire of 1879 (11). Collections were again started and during the succeeding years contributions were made by Fathers Joseph Carrier, C.S.C., Alexander Kirsch, C.S.C., Julius A. Nieuwland, C.S.C., and Peter Hebert, C.S.C., and by Doctors Theodor Just and Albert Delisle. At the present time this herbarium, called the "Julius A. Nieuwland Herbarium," contains about 250,000 specimens, chiefly American plants, many of which have been received by exchange, purchase or gift. Father Nieuwland's own collection is the largest individual contribution. Dr. Edward L. Greene, botanical authority, gave to the University in 1914 his treasured botanical library of about 4,000 volumes and his irreplaceable herbarium of about 100,000 specimens, including the majority of types of the numerous new species of American plants described by him. This collection is kept as a separate "Edward Lee Greene Herbarium."

As previously mentioned, Father Neyron in 1870 introduced a "partial medical course," and a medical department was recognized (12). Interest in the study of medical subjects continued and "As early as 1885 medicine was an optional study during the Post-graduate Course" (13). By 1907 students were allowed to attend surgical clinics in St. Joseph's Hospital in South Bend. In the course of these years local physicians of South Bend taught most of the medical subjects. However, the University did not award Doctor of Medicine degrees and by 1918 most of the medical classes had been discontinued, however, a few were retained in the program for the bachelor's degree.

At the age of 63 Father Kirsch resigned as Director of the College of Science, and Rev. Julius A. Nieuwland, C.S.C. succeeded him and held the position from 1918 until 1923. In 1920, the Colleges of the University were reorganized and given their present instructional and administrative forms by the President, Rev. James A. Burns, C.S.C. Previous to this time the chief administrative officer of each college was called the Director; he now assumed the title of Dean. Up to this time there were no separate departments in the College of Science, although the equivalent organization was functioning in biology and chemistry (14). In 1920, the college of Science was organized into separate departments of biology, chemistry, physics, mathematics, astronomy, and pharmacy. The two last departments were discontinued by 1939, and a Department of Geology was established in 1948.

To permit him to devote all of his time to teaching and research, principally in chemistry, Father Nieuwland was relieved of his administrative duties in 1923. For years he had been doing research in acetylene chemistry, and in 1927 gained international recognition for his discovery of mono-vinyl acetylene which turned out to be the basis of a synthetic rubber. He was succeeded as Dean by Rev. Francis J. Wenninger, C.S.C., zoologist and Head of the Department of Biology, who held this position from 1923 until 1927, when Rev. George W. Albertson, C.S.C., bacteriologist and botanist, became Acting Dean while Father Wenninger was on leave of absence for studies in Europe. Father Albertson died in 1929 and Father Wenninger returned to Notre Dame and continued as Dean until his death in 1940.

Under Father Wenninger's able leadership significant progress was made in all of the departments in his College. The task was considerable for the enrollment of the University increased from 1,207 in 1920 to 3,343 in 1940 (15). More faculty, buildings and equipment were needed and rapid advances were being made in research in the Departments of Biology (Bacteriology), Chemistry (Organic Chemistry) and Physics (Nuclear Physics). The Science Hall, which housed the Departments of Biology, Mathematics and Physics, as well as the University Museum, was considerably enlarged in 1924; yet this did not suffice and a separate Biology Building was erected in 1937.

Dr. Henry Froning, Professor of Chemistry, was chosen as Father Wenninger's successor and acted in this capacity until his retirement in 1943. He was succeeded by the present dean, Dr. Lawrence H. Baldinger, Professor of Chemistry.

During the war, Navy and Marine trainees used the University facilities and much of the graduate and research work was curtailed due to heavy teaching schedules of the faculty, as the enrollment had been increased by the Armed Services to about 5,000, and it was necessary to teach three in place of two semesters each year. After the war, the University decided to retain this number of students as a quota. Consequently, more buildings were needed, more faculty and equipment were required so that the graduate and research program could again continue and be augmented.

This expansion has necessitated the erection of new buildings for the College of Science. A greenhouse near the Biology Building was erected in 1951. In 1952, three additional buildings: a large-production germ-free laboratory, an animal house, and a machine shop were completed for the expanding needs of Lobund. The Nieuwland Science Center, named in recognition of Father Nieuwland's work, was dedicated in 1953, and houses the Chemistry, Physics and Mathematics Departments, although the Chemistry Department still needs the use of the older Chemistry Hall.

Since the Nieuwland Science Center provided ample room for the Mathematics and Physics Departments, the old Science Hall was converted into a Student Center in 1953. This entailed the discontinuance of the Museum as a display collection. These collections were started as early as 1845, with the present of Dr. Cavalli of Detroit, Michigan. Previous to its destruction in the fire of 1879 this collection was considered "Apparently one of the better collections of its kind at the time" (9). With the gift of a collection of minerals and fossils by Rev. D. Clarke of Columbus, Ohio in 1880, efforts were renewed to rebuild the Museum. Fathers Zahm, Kirsch and Wenninger collected and received other valuable additions until 1940. In 1953 most of the botanical and zoological specimens were transferred to the Biology Building for teaching and research needs and the minerals were deposited with the Geology Department for the same purposes.

The collection of books for the University needs was begun by the Rev. August Lemonnier, C.S.C., fourth president of the University (1872-1874). In 1879 the library, which had grown to 10,000 volumes, was almost completely destroyed in the disastrous fire of that year (16). The present General Library Building was built in 1917 and now houses 274,404 volumes for the Colleges of Arts and Letters, and Commerce. Separate Colleges of Law and Engineering libraries are housed in their respective buildings. The College of Science libraries are in two buildings. Previous to 1893, the science collections were located in the Science Hall. When the first Chemistry Hall was built in that year, the chemistry collections were moved to these new quarters. In succeeding years the biology libraries were moved to the present Biology Building (1937) and the chemistry, mathematics and physics collections to the Nieuwland Science Center (1953).

The biology libraries, housed in separate rooms, consist of: The "Edward Lee Greene Botanical Library" of 2,900 volumes; the "Julius A. Nieuwland Botanical Library" of nearly 10,000 volumes, and the "Wenninger-Kirsch Zoological Library" of approximately 11,000 volumes (17). The physical sciences and mathematic libraries are housed together and contain over 18,000 volumes (18).

While the University has from the beginning been conducted by the Congregation of Holy Cross, with a large number of priests and brothers serving the faculty, there has always been a considerable number of lay professors. As a result of the rapid expansion the number of lay faculty members has increased. The faculty in the school year for 1953-54 numbered 564; 88 priests and brothers, 335 full-time lay faculty members, and 141 teaching fellows. In the College of Science there were 14 priests and brothers, 50 full-time lay faculty members, and 60 teaching fellows. In 1943, when Dean Baldinger assumed his duties as Dean, there were enrolled 295 undergraduate science majors and this number had increased to 663 in 1954. In concluding this sketch of the history of the development of the natural sciences at Notre Dame, therefore, it should be pointed out that all five of the departments offer undergraduate degree programs and that facilities for advanced training and research leading to the master's and doctor's degrees are available in the Biology, Chemistry, Mathematics and Physics Departments. Of the 383 graduate students enrolled in 1954, 135 were majors in the departments of the College of Science.

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MATHEMATICS

Chairman: RALPH HULL, Purdue University

HARRY E. CRULL, Butler University, was elected chairman for 1955

ABSTRACTS

Retraction, Homotopy, Integral. LAMBERTO CESARI, Purdue University.—Recent studies have shown that parametric surfaces in the ordinary space under the sole hypotheses to be continuous and to have finite area have remarkable analytical and geometrical properties which proved to be adequate in analysis and calculus of variations. The author has defined an integral $I(S) = (S)\int F(p,t)$ over a surface S of finite area as a Weierstrass integral ($F(p,t)$ is any continuous function of the point p and the direction t, and $F(p,kt) = kF(p,t)$ for $k > 0$). For the definition of $I(S)$ by a limit process the surface S is divided into pieces and the direction of an average normal to each piece can be defined by the help of topological methods. A. G. Sigalov, J. Cecconi, J. M. Danskin and the author have used the integral $I(S)$ for the proof of existence theorems of calculus of variations. The author has proved and applied lemmas concerning retraction and homotopy. Every surface S whose boundary B is close to a given simple curve C has a nondegenerate retraction S_0 whose boundary B_0 is also close to C. If B is contained in C and is not nulhomotop in C then B_0 is also contained in C and is not nulhomotop in C.

Extreme Points of Convex Sets. MEYER JERISON, Purdue University.—A bounded, closed, convex set in a finite dimensional vector space is the closed convex hull of its extreme points. If $[K_n]$ is a decreasing sequence of such sets, then their intersection, K, is also such a set. It is proved here that every extreme point of K is the limit of a sequence of extreme points of the sets $[K_n]$. If $[K_n]$ is an increasing sequence, then the union is convex. Letting K be the closure of that union and assuming that it is bounded, one obtains the same conclusion as in the preceding case.

With some slight changes, notably, replacing "bounded, closed" by "compact", the results become valid in an infinite dimensional space.

Mathematics for Teachers. CHARLES F. BRUMFIEL, Ball State Teachers College.—Current dissatisfaction with the job that the high schools are doing in preparing students for college work in mathematics is certainly justified. Any improvement in the high school program must come primarily from the high school teachers themselves. The immediate task, then, should be the creation of better training programs for teachers. In Indiana, high school and elementary teachers are required to earn the Master's degree within a few years of graduation in order to retain license to teach. This requirement that teachers follow a graduate program presents an opportunity to set up courses on the graduate level for both the elementary and high school teachers that will give them a better insight into the meaning of mathematics. Conventional graduate courses leading to research are of course impossible. Courses in foundations and History are in order. Moreover, it would seem desirable to consider whole areas of mathematics, as algebra, geometry, and analysis, and reorganize materials so that they may be presented to the high school teacher in such a way that he can relate them to his teaching and draw from them a living stimulus for his work.

Integrating Factors of $P(x,y,z)dx + Q(x,y,z)dy + R(x,y,z)dz = 0$. WILL E. EDINGTON, DePauw University. — The differential equation $P(x,y,z)dx + Q(x,y,z)dy + R(x,y,z)dz = 0$ is of considerable importance when integrable in interpreting solutions of partial differential equations, and frequently its solution is essential to the solution of a second order partial differential equation where Monge's method is used and it becomes one of Monge's equations used in determining an intermediate integral. In this paper an expression for an integrating factor of the above equation is put in such a form as to indicate or suggest a relation, often in functional form, that will lead to the solution of the equation. Certain exceptional cases are discussed and interpreted.

Periodic Solutions of Non-Linear Differential Equations. R. A. GAMBILL, Naval Ordnance Plant, Indianapolis.—Consider the system of differential equations

(1) $$y_j = \rho_j y_j + \epsilon q_j\,(y_1, \ldots, y_n, t; \epsilon), \qquad j = 1, \ldots, n,$$

where $\rho_1, \ldots, p_n$ are complex numbers, ϵ is a small parameter, and each q_j is a holomorphic function of $y_1, \ldots, y_n$, ϵ, for $|y_j| < A$, $|\epsilon| < \epsilon_0$, with coefficients periodic in t of period $2\pi/\omega$. The problem of interest here is to determine periodic solutions of (1) whose dominant terms have period $2\pi/\omega$ (harmonics), $2\pi n/\omega$, n an integer > 1 (subharmonics), or $2\pi/n\omega$, n an integer > 1 (ultraharmonics). General sufficient conditions are given for the existence of harmonics, subharmonics, ultraharmonics of (1) for $|\epsilon|$ small. At the same time, their approximate expressions are determined through a convergent process. The method used is a method of successive approximations which is a variant of the Poincaré method of casting out the secular terms. It is similar to the method used by L. Cesari for the determination of the characteristic exponents of linear systems with periodic coefficients, and to the method used by J. K. Hale for the determination of cycles of non-linear autonomous systems. The following results, among others, are obtained:

I. The numbers $\rho_j = ik_j\omega/m_j + 0(\epsilon)$ can be determined so that there is a periodic solution of (1) of the form

(2) $$y_j = a_j e^{ik_j\omega t/m_j} + \epsilon w_j(t;\epsilon), \qquad j = 1, \ldots, n,$$

k_j, m_j positive integers, a_j arbitrary complex constants, $|a_j| < A$, and $w_j(t;\epsilon)$ holomorphic in ϵ with coefficients of period $T = 2\pi m_1, \ldots, m_n/\omega$.

II. If $\rho_j = ik_j\omega/m_j$, and if

$$S_j(a_1, \ldots, a_n) = \frac{1}{a_j T}\int_0^T q_j\,(a_1 e^{ik_1\omega t/m_1}, \ldots, a_n e^{ik_n\omega t/m_n}, t; 0)\, e^{-\rho_j t}\, dt,$$

then there is a periodic solution of (1) of the form (2) if $S_j\,(a_1^\circ \ldots, a_n^\circ) = 0$, and the Jacobian $|\partial S_j\,(a_1^\circ, \ldots, a_n^\circ)\,/\partial a_k| \neq 0$. This condition on S_j has been obtained by Coddington and Levinson. Cases where the above Jacobian is zero are discussed when system (1) arises from a real system of second order differential equations.

PHYSICS

Chairman: George D. Van Dyke, Earlham College

Francis E. Throw, Wabash College, was elected chairman for 1955

ABSTRACTS

On Non-Equilibrium Carrier Concentration in Ge. Ralph Bray, Purdue University.—Deviations from equilibrium concentration of carriers in a Ge sample may be produced by passing current through the sample. The contacts to the sample are of primary importance in this effect. Depending on the method of making the contact, it is possible to produce situations where the minority carrier concentration at the contact is *greater* or *less* than in the interior. Passing current through the sample with the given contacts sweeps either an *excess* or *deficiency* of minority carriers into and through the sample. There is a consequent decrease or increase in sample resistance. The processes are respectively labeled injection and extraction. Control of the carrier concentration by the current, leads to control of sample resistance and of rectifying contacts, e.g. as in transistor action. Transient recovery after injection or extraction is by recombination or thermal generation of hole-electron pairs. The rate of reaction is characterized by the "lifetime."

On the Thermodynamics of Crystalline Lattices. Lewis S. Salter, Wabash College.—The computational problems involved in the quantitative discussion of the thermodynamics of ideal crystals are briefly reviewed; a general result is derived, based on a lemma established by Born[1], which materially simplifies the theory. It is shown that the Helmholtz free energy (and thus the other thermodynamic functions of interest) of the harmonically vibrating lattice is obtainable as the average over reciprocal space of the trace of a function of the dynamical matrix, without recourse to the normal mode distribution function $g(\omega)$.

On the Formation of Oxide Films on Chromium and Nickel-Chromium Steels in Air at 500° C. to 700° C.[2] H. J. Yearian, J. F. Radavich and W. D. Derbyshire, Purdue University.—A uniform polycrystalline film of oxide 100 to 500 A in thickness forms in the first few minutes of oxidation and grows very slowly thereafter. As oxidation proceeds the protectiveness of this base film fails at random positions and at random times, leading to the local formation of nodules of oxide which represent the majority of the metal loss. Those nodules grow and new ones continue to form until the whole base film is covered with a relatively heavy deposit constituting an incipient scale. The rate at which the process proceeds depends on alloy composition and temperature in the same way as does the scaling rate at higher temperatures.

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[1] Born, M. 1943. Theoretical investigations on the relation between crystal dynamics and X-ray scattering. Rep. Progr. Phys., 9, 294.

[2] Supported by the Office of Naval Research and by Project Squid, jointly sponsored by the Office of Naval Research and the Office of Air Research.

The composition and preferred orientation of the film and nodules will be discussed.

On the Effect of Reduction on the Low Temperature Heat Capacity of Rutile. P. H. KEESOM and N. PEARLMAN, Purdue University.—The molar heat of pure rutile (TiO_2) has been found to be proportional to T^3 in the liquid helium region, with a Debye $\Theta = 758°$ K., assuming 9N degrees of freedom. In the liquid hydrogen region, Θ decreases, reaching 460° K at 20° K. After slight reduction at 1000° C., the heat capacity in the liquid helium region increases greatly. Re-oxidation shows this effect to be approximately reversible. The increase also depends on the degree of reduction. The additional heat capacity appears to be constant from 1° to 13° K., and then to decline to zero by 16° K. Reduced rutile is a semiconductor in which the electrons have a very high effective mass. A possible explanation of the observed increase is that each "free" electron contributes its classical value, $3k/2$, to the heat capacity.

On Varieties of Nuclear Shell Model. DAVID C. PEASLEE, Purdue University.—The nuclear shell model has several variations: j-j coupling versus L-S, single-particle versus collective states. The L-S coupling appears mainly in light nuclei, the collective states in heavy nuclei, and the j-j single-particle model has some applicability throughout the entire periodic table.

A survey will be given of present evidence on each of these variant models and their range of validity.

On a Fast Cycling Cloud Chamber. FRANK S. MATHEWS and HALSEY L. ALLEN III, Purdue University.—In order to make better use of the γ-ray beam from the Purdue 300 Mev synchroton, the 14" cloud chamber has been modified for fast cycling. By overcompressing the chamber quickly after fast expansion, the gas is heated up and the droplets are vaporized so that the chamber is ready for another exposure. It has been possible to decrease the cycle time to 7 seconds although operation is better at 12 seconds. This is to be compared with the 60 second cycle used before. Although there are still some problems of turbulence, clear pictures are obtained.

The cloud chamber is being used at the present time to study the production of mesons by the 300 Mev γ-ray beam on various elements. The mesons are recognized and distinguished from protons by the variation of ionization with range and by multiple scattering on plates placed in the cloud chamber.

On the Measurement of Nuclear Moments of Excited States of Nuclei. ROLF M. STEFFEN, Purdue University.—One of the most valuable tools of nuclear spectroscopy for the determination of angular momenta and parities of excited states is the study of the angular correlation and the polarization direction correlation of successive nuclear radiations emitted from these states. In some cases the angular correlation is altered by electric and magnetic fields acting on the electric and magnetic moments of the nucleus. These fields may be externally applied fields or may be due to atomic, molecular, or crystal structure. A measurement of the magnetic moment and the electric quadrupole moment of excited nuclear states then becomes possible. Moreover, the dependence of the angular correlation on the chemical and physical state of the radioactive source can provide information about the electric and magnetic fields prevailing at the decaying nucleus, and thus could give information on atomic and molecular structure and the structure of liquids and solids just as do nuclear magnetic resonance absorption and nuclear induction.

On a New Theory of Gravitation and Its Quantization. FREDERIK J. BELINFANTE, Purdue University.—Einstein's theory of gravitation in many regards is the most elegant theory of gravitation in existence. Its only disadvantage is the complicated form of its equations, which are not "linear" in the gravitational field, so that according to Einstein the "superposition principle" would not be valid for gravitational fields from different sources. This nonlinearity also makes its quantization much harder.

We have therefore formulated a somewhat simpler theory of gravitation, which is linear, and which it is easier to quantize. This new theory can explain the same experimental facts that Einstein's theory can explain. As far as perhaps the bending of light along the sun according to the experimental data does not exactly fit Einstein's theoretical value, the present theory can fit these data even better.

As for the red shift in the solar and stellar spectra, there is no possibility of comparing theory and experiment, as there are red shifts of a different origin related in some way with the temperature of the star, which cover up the effect pretty completely, and which are not understood theoretically at all. There may be reason to believe that the gravitational contribution to this red shift is much smaller than predicted by Einstein. Unfortunately, a first crude calculation of this effect according to the new theory leads to exactly the same prediction as made by Einstein, so that our theory is no improvement in this regard.

In general it should be said that the theory proposed by us is inferior to Einstein's theory from a philosophical point of view. Einstein starts from the general principle of relativity, and can directly derive his gravitational theory. Only one constant of interaction between matter and gravitation appears. We assume no general but only special relativity. Therefore, we had a much wider choice of theories. Our theory contains at the outset a large number of unknown constants. These are adjusted to explain the experimental data. Such a procedure is much more arbitrary than the one followed by Einstein.

Attempts at quantization of Einstein's theory itself therefore remain of interest, as long as it has not been definitely established that Einstein's theory would contradict the experimental facts. New attempts at such quantization by Gupta have had some success, and further development of this theory is desirable.

PSYCHOLOGY

Chairman: Edward T. Jordan, Indiana State Teachers' College
Barron B. Scarborough, DePauw University, was elected
chairman for 1955

ABSTRACTS

The Effects of Two Experimental Counseling Techniques on Performances Impaired by Induced Stress. Morton Wiener.—The present study was designed to examine the effectiveness of experimental therapy in improving performances previously impaired by experimentally induced stress. A further aim was that of throwing light on the question of the relative effectiveness of two counseling techniques: Reassurance-Interpretation and Catharsis-Reflection.

Subjects consisted of 90 undergraduate students, divided into non-stress (N-30) and stress (N-60) subgroups. For the latter, stress was induced by implying that a Rorschach, which these Ss had taken earlier, had been interpreted and indicated possible maladjustive features. Comparison of stress and non-stress groups on a pretest battery, consisting of Thematic Apperception Test, Wisconsin Card Scoring Test, Mirror Tracing, and an Attitude Scale indicated that the stress group tended to be more impaired in their performance; differences between stress and non-stress groups were consistent although not always significant statistically. Immediately following the stress situation and the pre-testing, the stress group Ss were divided into four subgroups: I. Reassurance-Interpretation; II. Catharsis-Reflection; III. Talk; IV. Rest, which were the experimental conditions.

At the conclusion of the experimental counseling, the posttest battery was administered to all Ss. The basic unit of analysis was the difference score (pretest minus posttest score). Comparison of the performance of the two counseled subgroups combined and the two non-counseled groups combined, indicate that the counseled groups showed quite consistent, though not always significant improvement on posttest measures than the non-counseled. There were no indications, however, that either of the two experimental counseling techniques was more effective in improving performance than was the other.

Despite the fact that the results can only be viewed as suggestive rather than conclusive, that there are no differences between counseling techniques because of limitations noted in the discussions, there is reason to believe that this general type of design is a fruitful one for studying the complex problems of evaluation of psychotherapy and psychotherapeutic techniques.

A Comparison of Normals, Psychoneurotics, and Psychotics or Rorschach Determinant Shift. Robert G. Gibby, Bernard A. Stotsky and Robert W. Harrington, Veterans Administration Hospitals, Marion, Indiana, and Brockton, Mass.—The results of previous studies have shown that determinant shift, a method of measuring changes which occur from free association in inquiry of the Rorschach, has value as an experimental technique for research with the Rorschach Test. One possible interpretation of shift has been as a measure of the adaptability of an individual to a sudden change in the testing situation. The degree of shift could possibly be used as a measure of flexibility. Lack of shift in a record would then be interpreted as a sign of inability or lack of motivation to respond effectively to the changed situation. If so, we would expect normals to show greater ability to shift. It is also possible that a lack of shift may be indicative of an ability to maintain consistency of response in the face of an uncertain situation brought about by the sudden change from the unstructured free association to the relatively structured inquiry. Thus, lack of shift may indicate retention of control in an uncertain, possibly stressful situation. If this were true, normals would tend to shift less than either psychotics or psychoneurotics. The purpose of this study was to determine which of these two interpretations of determinant shift was more tenable.

1. Thirty-five normals, 240 psychoneurotics, and sixty psychotics were compared for determinant shift from Rorschach free association to inquiry by the arc-sine method. Six determinants, *F*, *M*, *FC*, *CF*, *FY*, and *YF*, were studied.

2. Normals showed significantly greater shift than psychoneurotics on *FC*, *CF*, and *YF;* significantly less on *M*. Normals also shifted more than psychotics on all determinants, with the differences for *F*, *CF*, and *YF* attaining statistical significance.

3. Psychoneurotics showed more shift than psychotics on five of the six determinants studied. On the sixth, *FC*, there was a negligible difference in favor of psychotics. Differences in shift for *F*, *M*, and *FY* were significant.

4. The findings were regarded as favoring an interpretation of determinant shift as a measure of sensitivity and adaptability to changes in the stimulus situation. The differences between groups were discussed in the light of Rorschach theory and experimental findings.

A Study of Job Interrelationships. ERNEST J. MCCORMICK, Purdue University.—An R-technique principal components factor analysis was carried out involving 44 worker oriented variables that had been rated on 4,000 jobs (these data were furnished by the U. S. Employment Service). The variables consisted of two Training Time variables, twelve Aptitude variables, six Physical Demands variables, twelve Temperament variables, five Interest variables, and seven Working Conditions variables. Each of 4,000 jobs taken from the Dictionary of Occupational Titles was rated on these variables by U. S. Employment Service analysts. The following factors were ultimately identified:

1. Mental and Educational Development vs. Adaptability to Routine
2. Adaptability to Precision Operations
3. Body Agility
4. Artistic Ability and Esthetic Appreciation
5. Manual Art Ability

6. Supervisory Ability vs. Adaptability to Routine
7. Clerical Ability vs. Heavy Manual Work

For each factor a regression equation was derived, using the four variables that gave the highest multiple correlation with factor values. These regression equations were then used in obtaining factor scores for each job.

Factor Score "levels" were then obtained by dividing each distribution of factor scores into a "high" level (coded 2) and a "low" level (coded 1); for factor one, three levels were made, high, average, and low. Thus, there was a factor score level for each factor, for each of the 4,000 jobs.

Patterns of job requirements were then identified in terms of the permutations of the factor score levels of the seven factors. A total of 192 permutations was possible. Actually, the jobs fell into 115 patterns, with most jobs being concentrated in a limited number of patterns; for example, 88 per cent of the jobs fell in one of 33 patterns.

The results indicate that, in terms of patterns of job requirements, jobs tend to be concentrated in a limited number of molds.

A Test of the Magnetic-Vertical-Coriolis Theory of Homing.[1] ARTHUR R. ORGEL and JAMES C. SMITH.—The present study attempts to determine by use of the conditioning technique whether pigeons are sensitive to a changing magnetic field. Two homing pigeons were given training in buzz-shock, light-shock, and magnetic field-shock sequences. Trials were run in a lucite cage, the floor of which was an electric grid. Shock was adjusted during each session to be of sufficient strength to cause the birds to jump from the grid. The conditioned stimuli (buzz, light, or magnetic field) were all of two second duration and were overlapped by a shock of .11 seconds duration. The conditioned response of walking or running to the sound of the buzzer or the presence of light appeared in both subjects. It took approximately 800 trials to reach a 95% criterion of conditioning with the buzzer; for light it took approximately 150 trials; for the magnetic field no conditioning appeared after 1,000 trials. The failure to establish conditioning in pigeons subjected to the magnetic field-shock sequence would tend to cast doubt on the fundamental hypothesis of Yeagley's Magnetic-Vertical-Coriolis theory of homing—that pigeons are able to home because of their sensitivity to the earth's magnetic field.

The Measurement of Anxiety in Clinical Situations and Its Relationship to the Taylor Anxiety Scale. ARNOLD BUSS, MORTON WIENER, ANN DURKEE, MARC BAER.—Anxiety is a construct that subsumes a variety of behaviors. In this study, the behavior of psychiatric patients was observed in an interview situation, the focus being on the manifestations of anxiety. There were three goals: (1) To separate out the various aspects of anxiety and to determine the interjudge reliability of rating each aspect; (2) To determine the relationship of each aspect of anxiety to a global rating of anxiety; and (3) To use the ratings of anxiety as a criterion against which to validate the Taylor Anxiety Scale.

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[1] The authors wish to express their gratitude to Drs. Winthrop N. Kellogg and George Ragosa and to Mr. Robert Kohler for their invaluable assistance in this study.

The subjects were 73 patients in a neuropsychiatric hospital. Each subject was interviewed in a room with four psychologists who rated anxious behavior. Then the subject was taken to another room where the Taylor Anxiety Scale was administered by another staff member.

Anxious behaviors were divided into two classes: *Observed*—Distractibility, Restlessness, and Physiological Concomitants and *Reported:* Feelings of Panic, Worry, Somatic Complaints, Physiological Concomitants, and Muscular Tension. Finally, there was an Over-All Rating of Anxiety.

The ratings of each judge were compared with those of every other judge. The mean inter-correlation for over-all anxiety of .83 indicates fairly high inter-rater reliability. Next the judges' ratings were pooled and the pooled ratings were used in all subsequent comparisons. The correlations between each of the individual categories and the over-all evaluation of anxiety suggest a definite relationship between global anxiety and the individual components.

Finally, each category was correlated with the Taylor Anxiety Scale. As expected, the reported aspects of anxiety correlated better with the Taylor Scale than the observed aspects. The over-all rating correlated .60 with the Taylor Scale, which suggests that the Taylor Scale is a fairly adequate measure of anxiety as seen in psychiatric patients.

A Comparison of Motivational Conditions of Maze Learning in Fish. ROBERT D. MYERS.—Twelve goldfish termed group motivated and twelve goldfish termed non-group motivated were given ten trials a day for three consecutive days in a specially constructed four choice-point multiple U fish maze. The group motivated subjects were stimulated by intense light plus three goldfish in the goal area; the non-group motivated were stimulated only by intense light.

The purpose of the experiment was to investigate the effect of a group motivating factor on the maze learning capacity of goldfish. The results in time and errors per trial showed that there are large and statistically significant differences between the group and non-group motivated fish. The performance of the group motivated fish was superior to that of the non-group motivated.

It was suggested that interstimulation between the goldfish in the goal area and the group motivated subject raised the activity level which might account for differences between groups.

It was indicated that goldfish acquire a complex maze habit when motivated by intense light stimulus. Furthermore, goldfish perform a complex maze task more proficiently when acting under an additional motivating factor in the form of a group.

A Socio-psychological Investigation of Attitude Change. ROBERT E. MAINER.—An eleven item scale of attitude toward social discrimination was administered in September, 1952, and again in March, 1953, to a nation-wide sample of 7,472 high school pupils. For 1,823 of these pupils, responses made in September could be compared with those given the following March. Difference scores were obtained and transformed into an index of attitude change. While the split-half reliability of the scale was quite satisfactory ($r_{tt} = .87$), a high correlation between administrations of the scale caused the estimated reliability of the change scores to be extremely low.

Correlations of 15 other socio-psychological variables with the rather unreliable criterion of attitude change proved to be very low, although seven were different from zero at better than the five per cent level of significance. A series of seven analysis of variance problems showed grade, vocabulary level, and exposure to intergroup education programs to be related significantly to attitude change. Furthermore, region, religion and authoritarianism all entered into interactions with intergroup education programs to produce effects upon attitude change.

Discussion and interpretations of findings are provided. Etiological factors are hypothesized to account for differences in the effectiveness of attitude modification programs, and future research to explore the roles of such factors in attitude change is suggested.

TAXONOMY

Chairman: J. O. COTTINGHAM, Indianapolis

A. A. LINDSEY, Purdue University, was elected chairman for 1955

ABSTRACTS

A Rare Tolypella New to the United States of America. FAY KENOYER DAILY, Butler University.—In a small lake near Laramie, Wyoming, Dr. C. L. Porter of the University of Wyoming recently collected a Tolypella which appears to belong to the dioecious *Tolypella hispanica* Nordst. This is a rare species new to the United States of America.

Descriptions and illustrations give a comparative study of the collection from Wyoming with the holotype of *Tolypella hispanica* Nordst. and a collection of *Tolypella hispanica* var. *microcephala* Nordst. *Tolypella hispanica* var. *Porteri* nov. var. is formed.

Indiana Plant Distribution Records, XV, 1954

Genera are listed in the order used in Deam's Flora of Indiana, and species are given alphabetically within the genera. Symbols following the county in which the specimens were collected indicate the herbaria in which confirming specimens have been deposited. IU, B, ND, NW stand for Indiana University, Butler University, Notre Dame University and Northwestern University respectively. Entities considered worthy of being newly listed as part of the state's natural or adventive flora are given in bold face followed by literature reference and name of collector. Nomenclature is in accord with that used in Gray's Manual of Botany, 8th ed., 1950.

Specimens have been reported by the following collectors: P. E. Hebert, c. s. c., J. E. Potzger, J. A. Steyermark and F. A. Swink (Rhodora 54, p. 212), and Helene Starcs.

Starred names indicate the report of P. E. Hebert c. s. c. in Am. Midland Nat. **46**: 766-767. 1951.

A card file is maintained at the Botany Department of Butler University showing published distribution of each entity within the state. Anyone in need of such information may obtain it from this file. This report was prepared by J. E. Potzger and Helene Starcs.

Taxonomic Entities

Ophioglossum vulgatum, Crawford (B). *Typha angustifolia,* Bartholomew (B). *Bromus tectorum,* Delaware (B, IU). *Eragrostis pilosa,* Cass (B). *E. hypnoides,* Bartholomew (B). *E. pectinacea,* Bartholomew (B). *Dactylis glomerata,* Delaware (B, IU). *Elymus riparius,* Sullivan (B, IU). **Agrostis scabra,* St. Joseph (ND). **Alopecurus carolinianus,* St. Joseph (ND). **A. pratensis,* St. Joseph (ND). *Eleusine indica,* Bartholomew (B). **Bouteloua curtipendula,* St. Joseph (ND). *Panicum microcarpon,* Sullivan (B, IU). *Setaria faberi,* Clay (B, IU).

Cyperus erythrorhizos, Sullivan (B). *C. ferruginescens,* Bartholomew (B). *C. inflexus,* Bartholomew (B). *C. rivularis,* Delaware (B), Sullivan (B), *C. tenuifolius,* Sullivan (B).

Scirpus atrovirens, Sullivan (B). **S. debilis,* St. Joseph (ND). *S. lineatus,* Hamilton (B), Johnson (B). *S. validus* car. *creber,* Bartholomew (B). *Eleocharis acicularis,* Marion (B), Sullivan (B). *E. calva,* Bartholomew (B), Delaware (B), Hamilton (B), Johnson (B), Madison (B). **E. engelmanni,* St. Joseph (ND). *E. intermedia,* Marion (B). *E. smallii,* Hamilton (B). *Fimbristylis autumnalis* var. *mucronulata,* Sullivan (B).

Carex albursina, Monroe (B). *C. alata,* Hamilton (B), Kosciusko (B). **C. alopecoidea,* St. Joseph (ND). *C. artitecta,* Marion (B). **C. atherodes,* St. Joseph (ND). *C. brevior,* Delaware (B). *C. cephalophora* (B). *C. careyana,* Monroe (B). *C. cristatella,* Bartholomew (B), Delaware (B). *C. davisii,* Johnson (B). **C. debilis* var. *rudgei,* St. Joseph (ND). **C. frankii,* St. Joseph (ND). *C. granularis,* Bartholomew (B), Delaware (B). **C. gravida* var. *lunelliana,* St. Joseph (ND), *C. grisea,* Delaware (B). **C. hirsutella,* St. Joseph (ND). *C. hitchcockiana,* Monroe (B). **C. hyalinolepis,* St. Joseph (ND). *C. hystricina,* Bartholomew (B), Johnson (B). *C. jamesii,* Johnson (B). *C. lacustris,* Delaware (B), Jay (B). *C. laevivaginata,* Delaware (B), Johnson (B). *C. lanuginosa,* Delaware (B). *C. laxiflora,* Bartholomew (B). *C. leavenworthii,* Ripley (B), Marion (B). **C. leavenworthii,* St. Joseph (ND). *C. lurida,* Delaware (B). **C. mesochorea,* St. Joseph (ND). *C. molesta,* Madison (B). *C. oligocarpa,* Ripley (B). *C. platyphylla,* Jay (B). **C. stipata** var. **maxima,** Porter (B). Collected by L. M. Umbach (1900) and reported by F. J. Hermann in Am. Midl. Naturalist 51, p. 276. 1954. (Deam Herbarium.) *C. stricta* var. *strictior,* Delaware (B). *C. suberecta,* Delaware (B). **C. Texensis,** Am. Midland Nat. 51, p. 276. 1954. Posey (Hermann Herb.) *C. tribuloides,* Delaware (B), Hamilton (B), Sullivan (B). **C. Vulpinoidea** var. **Pycnocephala,** Steuben (Deam Herbarium). Collected by C. C. Deam, described by F. J. Hermann, Am. Midl. Nat. 51, p. 272. 1954. *C. willdenowii,* Bartholomew (B).

Juncus biflorus Bartholomew (B). *J. dudleyi,* Delaware (B). *J. effusus* var. *solutus,* Sullivan (B). *J. tenuis,* Bartholomew (B), Delaware (B), Sullivan (B).

Hemicarpha micrantha, Bartholomew (B). *Pontederia cordata,* Sullivan (B). *Veratrum woodii,* Ripley (B). *Rumex altissimus,* Bartholomew (B). *R. obtusifolius,* Bartholomew (B). *Silene nivea,* Hancock (B). **Trautvetteria caroliniensis,** Benton (NW). Collected by E. F. Shipman in 1876, reported by J. A. Steyermark and F. A. Swink, Rhodora 54, p. 212, from a specimen discovered in herbarium collection of Northwestern University. **Berteroa incana,* St. Joseph (ND). *Liquidambar styraciflua,* Bartholomew (B). **Cassia fasciculata,* St. Joseph (ND). **Vaccinium corymbosum** var. **glabrum,** Porter (Chicago Nat. Hist. Museum). Collected by F. A. Swink, published in Rhodora 54, p. 213. 1954. **Melissa officinalis,* St. Joseph (ND). *Conobea multifida,* Bartholomew (B). *Utricularia gibba,* Sullivan (B). **Artemisia annua,* St. Joseph (ND). **Lactuca floridana,* St. Joseph (ND). **Hieracium aurantiacum,* St. Joseph (ND).

Higher Fungi of Marion County, Indiana, VII

JOHN O. COTTINGHAM, Indianapolis

Agaricaceae
  Lepiota farinosa Pk.
  Trogia crispa Fr.

Boletaceae
  Boletus sub-fraternus Pk.

Hydnaceae
  Hydnum strigosum Swartz.

Lycoperdaceae
  Calvatia rubro-flava (Cragin) Lloyd.

Polyporaceae
  Polyporus squamosus Fr.

Total Species Reported 378.

We are indebted to J. C. Tacoma of Indianapolis for supplying the rare pink *Calvatia rubro-flava.*

A Key to the Subgenera of Synchytrium

JOHN S. KARLING, Purdue University

Synchytrium is the largest and most commonly known of the chytridiaceous genera and includes at present nearly 200 reported species which are obligate parasites of algae, mosses, ferns and flowering plants. On the basis of differences in life cycle and type of development the known species may be grouped into seven subgenera as follows:

A. Life cycle including sporangial sori and resting spores.
  1. Mature thallus functioning as a prosorus; contents emerging from initial cell of thallus to form a thin-walled sorus which cleaves into sporangia.
    a. Resting spore functioning as a prosorus in germination; contents emerging to form a thin-walled sorus which cleaves into sporangia.
      Subgenus *Microsynchytrium*
    b. Resting spore functioning as a sporangium in germination and giving rise directly to zoospores.
      Subgenus *Mesochytrium*
  2. Mature thallus functioning directly as a sorus of thin-walled sporangia; sporangia delimited by cleavage within the sorus wall and freed by its rupture.
    a. Resting spore functioning as a sporangium in germination and giving rise directly to zoospores.
      Subgenus *Eusynchytrium*
    b. Resting spore functioning as a prosorus in germination; content emerging to form a thin-walled sorus which cleaves into sporangia.
      Subgenus *Exosynchytrium*

B. Life cycle including only sporangial sori, or resting spores.
  1. Only sporangial sori known.
    a. Mature thallus functioning directly as a sorus of thin-walled sporangia; sporangia delimited by cleavage within the sorus wall; freed by its rupture, and appearing as powdery masses in open aecidium-like pustules.
      Subgenus *Woroninella*
  2. Only resting spores known.
    a. Resting spore functioning as a prosorus in germination.
      Subgenus *Pycnochytrium*
    b. Resting spore functioning directly as a sorus in germination.
      Subgenus *Endosynchytrium*

This key varies to some extent from the one proposed by the author in 1953, in that the subgenera of species with the long and more complex life cycles are placed first. This position is based on the working hypothesis, proposed by the author (1954), that the complex aquatic species might be the most primitive, and that as species began to parasitize terrestrial plants the life cycles became less complex and shorter. It is equally plausible, on the other hand, that the short-cycled species might be the most primitive, and through them have evolved the most complex species of *Synchytrium.*

Literature Cited

KARLING, J. S. 1953. *Micromyces* and *Synchytrium.* Mycologia **45** : 276-287.
————. 1954. Possible Relationships and Phylogeny of *Synchytrium.* Bull. Torrey Bot. Club **81** : 353-362.

New Chromosome Numbers in *Helianthus* and Related Genera (Compositae)

Charles B. Heiser and Dale M. Smith, Indiana University[1]

A detailed report on the chromosome numbers in the perennial species of *Helianthus* has never been published. Now that chromosome determinations are available for over one-half of the North American species of sunflowers it seems desirable to present an annotated list of the counts. All the new counts reported here were secured from microsporocytes smeared in acetocarmine. Voucher specimens are deposited in the herbarium of Indiana University.

Examination of Table 1 reveals that a polyploid series is present within the perennial sunflowers, with 17 species diploid, 4 tetraploid, and 7 hexaploid. It would seem that polyploidy is confined to the perennial species, for the six annuals previously reported are all diploid (3). To this list of annuals may be added *Helianthus agrestis* Pollard (n=17, Pinellas Co., Fla., *R. K. Godfrey 50848)*, and *H. praetermissus* E. E. Wats. (n=17, Pecos Co., Texas, T. Odell [*Heiser 5246*]; n=17, Valencia Co., N. M., P. Weatherwax [*Heiser 5245*]). One annual species, *H. anomalus* Blake, still remains to be counted.

Perhaps the most difficult species from a taxonomic standpoint is *Helianthus strumosus*, which Watson (8) segregated into numerous "species." Certain of Watson's species are listed in Table 1 under *H. strumosus*. It is now apparent that *H. strumosus* comprises both tetraploid and hexaploid populations which may account for some of the taxonomic difficulties. A detailed cyto-taxonomic study of this group is now underway by the junior author.

Helianthus heterophyllus is reported as a diploid in Table 1, but material from other sources (Jackson Co., Miss., *Heiser 4019* and Walton Co., Fla., *Heiser 3223*) shows a highly irregular meiosis with the presence of both univalents and trivalents. It seems probable that these plants are triploids.

In a previous note (4) it was stated that *Helianthus hirsutus* was diploid. The specimen upon which the count was based has now been determined as *H. divaricatus* and counts on *H. hirsutus* have shown it to be tetraploid. In this same paper *H. pumilus* was reported as diploid, but careful study of the herbarium material has shown that this specimen should probably be referred to *H. Nuttallii.*

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[1] This study was aided by grants from the National Science Foundation (N.S.F.-G18) and the American Philosophical Society (No. 1146).

TABLE 1

Chromosome numbers in the perennial species of *Helianthus*.

Species	n Chromosome Number	Previous Report	Source and Specimen Number
H. atrorubens L.	17		Louisa Co., Va., J. T. Baldwin, Jr., P45
	17		McDowell Co., N. C., Smith 1077
H. californicus DC.	51		Solano Co., Calif., Heiser 1972
	51		Napa Co., Calif., G. L. Stebbins & Heiser, P304
H. carnosus Small	17		Volusia Co., Fla., Heiser 3184
H. ciliaris DC.	51		St. Clair Co., Ill., Heiser 3097
H. Cusickii A. Gray	17		Yakima Co., Wash., A. T. Kruckeberg, P306
H. decapetalus L.	34		Monroe Co., Ind., Heiser 3005, 3017
	34		Monroe Co., Ind., Smith 1081
H. divaricatus L.	17		Brown Co., Ind., Heiser 3099
	17		Jay Co., Ind., Smith 1049
H. giganteus L.	17	(2)	
H. gracilentus A. Gray	17		Los Angeles Co., Calif., Heiser 1939
H. grosseserratus Martens	16	(1)	
	17	(2)	
	17		St. Louis Co., Mo., Heiser 1490
H. heterophyllus Nutt.	17		Okaloosa Co., Fla., Heiser 4023
H. hirsutus Raf.	34		LaGrange Co., Ind., C. C. Deam, P65
	34		McCreary Co., Ky., Smith, P132
H. laetiflorus Pers.	51		Cultivated, Heiser 3112
H. laevigatus T. & G.	34		Pendleton Co., W. Va., Smith 1065
H. Maximiliani Schrad.	17	(2)	
	17		Cass Co., N. D., O. A. Stevens, P28
H. microcephalus T. & G.	17	(2)	
	17		Brown Co., Ind., Heiser, P77
H. mollis Lam.	17		St. Louis, Mo., Heiser 1818
H. niveus (Benth.) T. S. Brandeg.	17		Yuma Co., Ariz., Smith, P193
	17		Puerto Kino, Sonora, Mex., R. Felger, P198
H. Nuttallii T. & G.	17		Wyoming, R. J. Davis, P47
H. occidentalis Riddell	17	(2)	
	17		Texas Co., Mo., Heiser 3095
H. radula (Pursh) T. & G.	17		Alachua Co., Fla., L. E. Arnold, P50
H. rigidus (Cass.) Desf.	51	(7)	
	51		Cass Co., N. D., O. A. Stevens, P29
	51		Lawrence Co., Ind., Heiser 3111
H. salicifolius A. Dietr.	17	(2)	
	17		Cultivated, Heiser, P115
H. silphioides Nutt.	17		Hickman Co., Ky., Deam, P61

Species	n Chromosome Number	Previous Report	Source and Specimen Number
H. strumosus L.	51	(7)	
	51		Greenville Co., S. C., Heiser, P140
H. arenicola E. E. Wats.	34		Dane Co., Wis., Heiser, P134
H. chartaceus E. E. Wats.	34		Tippecanoe Co., Ind., Smith 1022
H. leoninus E. E. Wats.	34		St. Clair Co., Ill., Heiser, P9
H. montanus E. E. Wats.	51		Blount Co., Tenn., Smith 1079
H. virilis E. E. Wats.	34		Greene Co., Ind., Smith, P298
H. tomentosus Michx.	51		Transylvania Co., N. C., W. C. Duncan 11960
	51		Wayne Co., Miss., Heiser 3236
H. tuberosus L.	51	(7)	
	51		St. Louis Co., Mo., Heiser, P5
	51		Posey Co., Ind., Heiser, P126
	51		Hennepin Co., Minn., G. Ownbey 1165

Chromosome counts were also obtained on a number of other members of the Heliantheae during the course of this investigation. (Table 2.) *Viguiera* appears to be the nearest relative of *Helianthus;* therefore, it is not surprising to find the number 17 in this genus. Of particular interest, however, is the presence of n=8 in *Viguiera multiflora.* It appears probable then that the number 17 in *Helianthus* and related genera may have been derived through allopolyploidy between an n=8 species and an n=9 species (as yet unknown). On this basis also it might be suggested that *Helianthus* may have been derived from *Viguiera,* although detailed study is necessary before definite conclusions can be reached.

TABLE 2

New chromosome numbers in miscellaneous species of the *Heliantheae.*

Species	n Chromosome Number	Source and Specimen Number
Echinacea purpurea Moench.	11	Cultivated, Heiser 3150
Iva ciliata Willd.	17	Posey Co., Ind., Heiser 7-8-51
Phoebanthus grandiflora (T. & G.) Blake	34	Sarasota Co., Fla., Heiser 3201
Rudbeckia laciniata L.	19	Cultivated, "Golden Glow," Heiser 3152
Tithonia tubaeformis (Jacq.) Cass.	17	Guerrero, Mexico, E. Hernandez X-3187
Verbesina alternifolia (L.) Britt.	34	Monroe Co., Ind., Heiser 3127
V. helianthoides Michx.	17	Franklin Co., Mo., Heiser 3149
V. occidentalis (L.) Walt.	17	Greenville Co., S. C., Heiser 3171
Viguiera cordifolia A. Gray	17	Pima Co., Ariz., Smith 1952
V. multiflora (Nutt.) Blake	8	Grant Co., Colo., D. & B. Norby 548
Zexmenia frutescens (Mill.) Blake	11	Turrialba, Costa Rica, Heiser 3342

Acknowledgements:

The counts for *Helianthus giganteus, H. grosseserratus, H. Maximiliani, H. Nuttallii,* and *H. salicifolius* have been verified by Dr. Robert Long (6), and those for *H. mollis* and *H. tomentosus* by Mr. Raymond Jackson (5). The count for *H. carnosus* was supplied by Miss Sarah Clevenger. Dr. William Weber has also counted n=8 in *Viguiera multiflora* (in litt.). It is also a pleasure to acknowledge the assistance of the many individuals listed in the table who supplied seeds or living material for study.

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ZOOLOGY

Chairman: JOHN D. MIZELLE, University of Notre Dame
JACKSON WEBSTER, Hanover College, was elected chairman for 1955

ABSTRACTS

The Isolation of *Endamoeba histolytica* from Experimental Infections in Rats. MAX C. MCCOWEN and MAURICE E. CALLENDER, The Lilly Research Laboratories.—In our laboratories we have experimentally infected young rats (30-35 gm) intracecally with the NIH 200 strain of *Endamoeba histolytica* associated with *Escherichia coli.* Since the Shaffer-Frye medium has been found to be satisfactory for maintaining strains of intestinal protozoa we have used the S-F medium to determine the culturability of *E. histolytica* from young rats with experimental infections.

Seven hundred twenty-five rats were examined by direct examination at autopsy and by use of the S-F medium at 37° C. Five hundred fifty-six rats were positive by direct examination. Samples from the cecal contents of 502 rats or 90.3 per cent subcultured positive in the S-F medium. One hundred sixty-nine rats were negative at autopsy but 70 or 41.4 per cent of the subcultures from the cecal contents of these negative animals became positive in the S-F medium.

A higher culturability rate was obtained with the S-F medium than with Egg Yolk Infusion medium or Boeck-Drbohlav medium.

The Use of the Ichthyokinometer for Measuring Pharmacological Activity. LT. THOMAS ADAMS, Purdue University.—The ichthyokinometer is a lever device attached to a fish by means of a thread and mounted appropriately to record the swimming movements on a moving kimograph drum. As the fish moves in the water the extent of its movements can be traced by the excursions of the writing lever. The influence of such factors as temperature, light and chemical agents can be measured qualitatively and quantitatively by an ichthyometer. Since the recording is due to active muscular movements it is suggested that the device be called an "ichthyokinometer." On display is such a device attached to a goldfish. The recording machine is a slow speed kymograph made by the Harvard Apparatus Co. of Dover, Mass. The drum makes one revolution in 10 hours. Some records are on display of the influence of certain drugs on the swimming activity of fish and are so labeled. Early and late effects of drugs can be seen by such a recording.

Studies on Monogenetic Trematodes. XVIII. Nature of the Attachment of Tetraonchinae to the Gills of Centrarchids. JEWELL E. BERRY, RALPH ONOFRIO and JOHN D. MIZELLE, University of Notre Dame.—Examination of sections of gills from four specimens of *Chaenohryttus gulosus* (Cuvier and Valenciennes) and one of *Micropterus salmoides* (Lacépède) revealed one hundred twenty tetraonchid parasites which were studied with regard to attachment to the host tissue. In every case, except one, the haptor of the parasites was inserted between adjacent gill filaments. Apparently, the attachment of these parasites causes no damage to the host since neither leucocytic infiltration nor other striking histological changes were observed.

The Locomotion of Frustules of *Craspedacusta*. SEARS CROWELL and CHARLES F. LYTLE, Indiana University.—One of the types of bud produced by the polyps of the freshwater jellyfish, *Craspedacusta sowerbyi*, Lank. is the frustule or planuloid. Those slowly move away from the parent over the substratum, settle down and transform directly into new polyps. This report describes the mechanism of creeping.

A rhythmic contractility of the body was made evident when continuous measurements were made of the length, width, and the position of the anterior end of the frustule. The tip moves forward rapidly as the diameter of the frustule is decreased. This tip then retracts slightly, and nearly comes to rest as the diameter of the body increases. Then a new cycle begins. The posterior end moves forward irregularly and appears to be drawn along by the activity of the anterior two-thirds of the frustule. A complete cycle takes about three minutes.

A three-minute cycle appears very slow for contractile tissues in Cnidaria. However, similar cycles of contractility of from two to seven minutes are known in stolons, and in the body of developing hydranths of *Obelia* (Hammett; Berrill).

The speed of creeping is only one to two millimeters per hour. Hence it would seem that the frustules are more significant in population increase than in dispersal of the species, unless perhaps the frustules are often moved by exogenous forces, such as water currents.

Some Effects of Colchicine Upon the Reproduction of *Paramecium caudatum*. SR. AGNES JOSEPH DONOVAN and ARTHUR L. SCHIPPER, University of Notre Dame.—An increase in the rate of fission was observed when *Paramecium caudatum* was cultured in media containing colchicine (0.000125, 0.00025, and 0.0005%). The division rate per day of the experimental animals averaged 9 to 15% higher than was noted for the controls. Acceleration was found to be in inverse ratio to the concentration employed. The time required for the initiation of conjugation of the animals reared in the experimental media averaged 25% less than for the controls. It was noted that a larger percentage of the colchicine-treated paramecia conjugated in comparison to the non-treated organisms. Greater activity was found in the colchicine-treated animals; the vitality of the cultures persisted longer. No cytological alteration of either the macro- or the micronucleus was observed as a result of exposure to colchicine.

The Trap-Door Spider, *Pachylomerides adouinii*, in Southern Indiana. SHERMAN A. MINTON, JR., Indiana University Medical Center.—The trapdoor spider, *Pachylomerides adouinii* Lucas, is reported from Indiana on the basis of an adult female collected near Floyd Knobs. This discovery provides further evidence that the southern portion of Knobstone Escarpment may be a survival pocket for certain southern animals.

Maintenance of the Killer Trait by kk Animals in *Paramecium aurelia*, Variety 4. P. K. CHAO, Indiana University.—When gene K of a killer of stock 51, variety 4, of *P. aurelia* is replaced by k, the animals become sensitive within 8 to 15 fissions at maximum fission rate at 27° C. A method has been discovered, however, for maintaining the killer trait in all kk cultures for more than 30 fissions and in about half of them for more than 100 fissions. The method is as follows: The kk-plus-kappa animals derived by autogamy from heterozygous Kk killers are kept at 14° C. for a period beginning after the first and extending until after the sixth post-fertilization fission. Thereafter, these cultures were maintained at 27° C. Such kk killers became sensitives in 15 fissions when they were put back at 14° C. after the 35th fission. Either autogamy or conjugation with isogenic culture d186 kk causes the loss of the killer trait. Moreover, the killer trait is lost if the original kk animals are kept at 14° C. from the start. The maintenance of kappa by kk animals (derived from Kk killers) thus depends upon the combination of a short early exposure to 14° C. followed by subsequent culture at 27° C.

Some Observations on the Behavior and Food Habits of Two Species of *Myotis*. CAMERON GIFFORD, Earlham College.—An account is given of weights of two species of *Myotis (M. sodalis* and *M. lucifugus)* and of the diets which were most successfully used for these in captivity. A record of food and weights was kept for three months. A description of the training of these bats to fly to the author for food is given, with other observations on behavior in captivity.

Acidophilic Granules in the Basophiles of Laying Hens. FERNANDUS PAYNE, Indiana University.—The cause of ovulation in birds has long been an interesting but unsolved problem. The experiments of Rothchild and Fraps with fowl clearly indicate a release of the ovulating inducing hormone from the pituitary between six and four hours before ovulation. A study of pituitary cytology demonstrates the presence of acidophilic granules in the gonadotropic secreting basophiles of laying hens and their absence in non-laying hens and cocks. There can be no confusion between these granules and mitochondria. The granules are presumed to be either a hormone or a chemical substance from which a hormone is derived. The fact that the acidophilic granules are found only in laying hens leads to the suggestion that they might be concerned with ovulation, but if so the release of the ovulating inducing hormone is probably cumulative rather than sudden.

The study further shows that a given cell type, the gonadotropic secreting basophile of the pituitary of the laying hen may secrete both basophilic and acidophilic granules. The presence of acidophilic granules in these basophiles in no way implies that they are chemically the same as the acidophilic granules in the acidophiles.

Bird Frequency of Delphi, Carroll County, Indiana. VIRGINIA ESTEN, Delphi.—A preliminary study of the bird population of Delphi and vicinity was made during the school year 1953-54. For this, forty-four field trips (averaging one hour each, from 7:45 a. m. to 8:45 a. m.) were taken as a part of a regular high school advanced biology class. Four routes were established and maintained; three located within walking distance of the school, inside the city limits, and the fourth about five miles east of the city limits.

On each trip, all birds seen or heard were recorded, with an attempt made to omit any duplication. Raunkaier's Law of Frequence was used to determine the frequency ratios of the 109 species reported. It was found that there was a correlation between this and other frequency studies using this law. The frequency rating for each species has been established to serve as a guide for further study of this problem.

Due to the time limits imposed, nocturnal birds have been slighted and there are no allowances made for effects of adverse weather changes. One must consider that this study covered three seasons of bird life (fall migration, winter, and spring migration) in one general area. Previous frequency studies were conducted daily during the breeding season.

However, it is believed that this study has laid the groundwork for further study and gives a reasonably clear picture of the bird life in and near Delphi during the school year. The use of Raunkaier's Law of Frequence is a reliable method to study bird population in a given area which can be compared with that of another area at the same time, or with the population of the same area at a different time.

Unusual Concentration of Bats of the Genus *Lasiurus* Found in a Missouri Cave. RICHARD F. MYERS, Cornell University, and ROBERT E. LEWIS, University of Illinois.—While collecting bats for banding in July and August of 1954, the discovery of specimens of both *Lasiurus borealis* (Muller) and *Lasiurus cinerius* (Beauvois) was made in a Missouri cave. This cave, located approximately eight miles north of Waynesville, Missouri, Pulaski County, is one of a series to be found in the bluffs bordering the Gasconade River. Fifteen living specimens and thirty-five skulls of *L. borealis* were taken while two living and three skulls of *L. cinerius* were kept for skins. Of the fifteen *L. borealis*, three were kept for skins and the remainder were banded and freed. The greatest concentration of remains was found in or around a large pile of rocks which had fallen from the roof of the cave about 500 yards from the entrance.

The presence of bats of this genus in caves is apparently rather rare, as only three past occurrences have been recorded. Attempts have been unsuccessful in ascertaining why these two species, both allegedly tree bats, were found in this particular cave. Much work on this problem remains to be done.

The Reoccurrence of the Freshwater Medusa Near Richmond, Indiana. MURVEL R. GARNER, Earlham College.—The appearance of the freshwater medusa, *Craspedacusta sowerbyi*, in an artificial pond was reported by the author before this body in 1931. Specimens continued to be found for a few summers, then they seemed to disappear. Numerous specimens were again taken in the late summer of 1954. This is believed to be the longest recorded interval of habitation by the species. A plea that future records of the species include more comprehensive data is made.

A Report on the Analysis of One Hundred Thirty-two Pellets of the Long-eared Owl, *Asio wilsonianus*. EARL F. GEORGE, Earlham College.—The pellets used in this study were taken from a pine planting in Jackson County, Indiana, during the period extending from February 4 to March 24, 1954. The classification of diagnostic bones was as follows: *Cricetinea*, to genus; *Microtinea*, to genus, except *Microtus ochrogaster* and *M. pennsylvanicus*, which were taken to species; *Sorecidae*, to genus; *Muridae*, to genus; *Aves*, to family, where possible. The total number of animals found was 249. The percentage relationship found between mice, shrews, and birds was as follows: mice, 89.1%; shrews, 2.4%; birds, 8.5%. The percentage relationship found between the categories of animals was as follows: *Peromyscus*, 51.4%; *Microtus ochrogaster*, 21.9%; *M. pennsylvanicus*, 4.3%; *Synaptomys*, .4%; *Mus*, .4%; *Unidentified Rodentia*, 10.4%; *Cryptotis*, 2.4%; *Fringillidae*, 2.8%; *Icteridae*, .4%; *Paserformes*, .4%; Undetermined *Aves*, 4.9%. Total *Aves* percentage, 8.5%.

Gene Testing in Collie Dogs. LEE FORD, Butler, Indiana.—One object of inbreeding is to get the individual as homozygous as possible, thereby "testing" the genes by seeing their phenotypic effects. After six years of "gene testing" in collie dogs, the following can be recorded: (1) Approximately 40% of the genes in this line were "tested" and found to be "good" genes. (2) Type of collie in all inbred litters is quite similar. (3) No color change or structural abnormality was noted. (4) Collies studied were tricolors (black, tan, white). The tan appeared to segregate into lighter and darker tan. (5) Size of all mature dogs not available, but apparently little or no decrease in size. (6) Bone structure is good. (7) No lack of vigor noted. (8) No decline noted in strength of constitution. (9) In females tested, litter size remains seven or more. (10) Dispositions improved, collies all friendly, curious, eager, lovable. (11) No noticeable increase in nervousness observed. (12) The collies have not lost their alertness nor intelligence from this inbreeding.

The Use of an Oxygen Dissociation Curve in the Interpretation of Animal Activity. CLARENCE J. GOODNIGHT, Purdue University.—The rapidity of response of animals to stimuli varies greatly among related forms. Some species are sluggish in habit, relying on some mechanism other than speed to obtain their food and to escape from their enemies. Others are fast and respond rapidly to danger or food.

Among the turtles, the box turtle, *Terrapene*, moves slowly and relies on closing up its shell to protect itself against attacks. On the other extreme, the snapping turtle, *Chelydra*, swims rapidly and responds by quick thrusts of its jaws to the presence of food or enemies. An examination of the oxygen dissociation curves obtained for these two species of turtles shows some of the physiological reasons for this difference. The oxygen dissociation curve for *Terrapene* is hyperbolic while that of *Chelydra* is sigmoid in shape. Thus *Chelydra* is able to unload oxygen at a much greater partial pressure of tissue oxygen than is *Terrapene*. This interesting correlation of activity and oxygen dissociation curve suggests possibilities of the use of these curves to help interpret animal activity.

Sodium and Potassium Movements in Frog Muscle Following Isolation to Ringer Solution of Varying Potassium Concentration. WILLIAM K. STEPHENSON, Earlham College.—Frog sartorius muscles were soaked at 2-6° C. for 24 hours in saline solutions with varying potassium and sodium concentrations ($K + Na = 110$ mEq./1.). Immediately after soaking the muscles were blotted, weighed, digested in HNO_3, and analyzed for K and Na with a flame photometer. In solutions with K concentrations of 0 to 4 mEq./l. K loss decreased markedly as the K concentration of the soaking fluid was increased. Above 4 mEq./l. of K, additional K in the soaking fluid did not decrease K loss, since K was retained at a concentration very near to that of fresh muscle. Within the range of K and Na concentrations used in the experimental solutions the average increase of fiber Na remained constant. Thus, a constant amount of Na moved into the fibers while varying amounts of K left the fibers. These results demonstrate that the passive movements of sodium and potassium in isolated frog muscle are not coupled.

(This work was carried out at the Univ. of Minnesota and was aided in part by Contract Nonr-24900 Office of Naval Research administrated by H. B. Steinbach.)

Studies on Monogenetic Trematodes XIX
The Status of North American Dactylogyrinae and Tetraonchinae

JOHN D. MIZELLE, University of Notre Dame

The genus *Dactylogyrus* was erected by Diesing (1850), to include Monopisthocotylea which were superficially similar to species of *Gyrodactylus*. The validity of this category was confirmed in 1933 when Bychowsky established the Dactylogyridae. Presently this family is composed of the subfamilies Bothitrematinae Price, 1936; Rhamnocercinae Monaco et al., 1954; Diplectaninae Monticelli, 1903; Dactylogyrinae Bychowsky, 1933; and Tetraonchinae Monticelli, 1903. The Bothitrematinae is distinguished principally by the presence of an almost complete circle of tubular structures on the haptor. Other characters are: cephalic glands scattered throughout the preoral area, one pair of anchors, two bars, and fourteen hooks. It consists of a single monotypic genus *(Bothitrema)*. The Rhamnocercinae is characterized principally by accessory cuticular armament on the haptor which differs from that in other subfamilies, and the possession of spine-like hooks throughout the length of the peduncle. Other characters include four anchors, three bars, and 12 or 14 hooks. This subfamily also consists of a single monotypic genus *(Rhamnocercus)*. The Diplectaninae is conspicuous by the presence of a squamodisc on each of the dorsal and ventral surfaces of the haptor. Other characters are: two pairs of anchors; two, three, or five bars, and 14 hooks (usually). This subfamily includes the genera *Diplectanum* Diesing, 1859; *Lamellodiscus* Johnston & Tiegs, 1922; *Lepidotrema* Johnston & Tiegs, 1922; *Neodiplectanum* Mizelle & Blatz, 1941; and *Squamodiscus* Yamaguti, 1934. The Dactylogyrinae and Tetraonchinae are remarkably similar morphologically. The most conspicuous difference consists of the presence of one pair of anchors in the Dactylogyrinae and two pairs of these structures in the Tetraonchinae. The haptor in these two subfamilies does not possess accessory cuticular structures.

The genus *Dactylogyrus* existed without question from 1850 to 1938 when Price defined *Neodactylogyrus* to include species of the former genus which possessed two "Haptoral hooks (anchors) supported by 2 similar or dissimilar bars." Since only one of these bars supports the anchors, the generic diagnosis is erroneous, in part. The single pair of anchors and the accompanying bar are situated in the dorsal portion of the haptor; the second bar is situated ventrally and is interpreted as a relict structure which once supported the bases of a ventral pair of anchors which disappeared in the evolution of these species. This statement presupposes a *Dactylogyrus* ancestor with a dorsal and a ventral pair of anchors, and receives support in the fact that all of the other Dactylogyridae except the Bothitrematinae (one species) possesses this ancestral condition. In some species of *Dactylogyrus* the relict ventral bar has increased in size beyond that of the functional dorsal bar; in others it is smaller; and in still others it is absent. In many species the ventral bar is so small that it cannot be observed with certainty and especially so in fixed specimens.

Neodactylogyrus therefore is rejected because the relict ventral bar on which it is based, is so variable that it fails to be a reliable structure and its use results in synonymy, which is to be avoided. Further, the present author does not consider this single structure to be of generic level. *Neodactylogyrus* has been recognized (Kimpel, 1939; Sproston, 1946), ignored (Malevitskaja, 1941; Mizelle & Klucka, 1953; Mizelle & Webb, 1953; Monaco & Mizelle, in press), and rejected Mizelle & Donahue, 1944. *Dogelius* Bychowsky, 1936 (monotypic), is the only other genus in the Dactylogyrinae.

The subfamily Tetraonchinae is composed of twenty recognized genera (Sproston, 1946). North American investigations on this subfamily began in 1932 with the description of *Urocleidus aculeatus* by Van Cleave and Mueller. Subsequent work proceeded so rapidly that some of the newly created genera were questioned by Mizelle and Hughes (1938) who reduced nine of these *(Actinocleidus, Aristocleidus, Cleidodiscus, Haplocleidus, Leptocleidus, Onchocleidus, Pterocleidus, Tetracleidus, Urocleidus,* all of Mueller) to three, namely *Actinocleidus, Cleidodiscus* and *Urocleidus.* Price defined the genus Murraytrema in 1937, Mizelle and Blatz described *Rhabdosynochus* in 1941, and Mizelle erected the genus *Anchoradiscus* in 1941. This makes a total of six valid North American genera. Whether or not some of these are sufficiently different from Old World genera to warrant recognition is not considered in this paper.

The present author feels that sufficient North American species have now been described to give a reasonably clear picture of this subfamily on this continent. *Murraytrema* Price, 1937, is distinct and warrants no comment as to its validity. Similarly, *Cleidodiscus* Mueller, 1934, with two pairs of anchors (dorsal and ventral), and two individual (disarticulated) bars supporting the anchor bases, a basally articulate cirrus and accessory piece, and a sinistral vagina (when present), presents a generic category of unquestioned validity. *Leptocleidus* Mueller, 1936(a), as a synonym (in part) of this genus (Mizelle & Hughes, 1938) is upheld. The coiled nature of the cirrus does not present a variation greater than that existing among other species of *Cleidodiscus* or *Urocleidus* Mueller, 1934, emended Mizelle & Hughes, 1938. In addition, the present author has on several occasions observed old specimens of *Cleidodiscus* to possess an enlarged trunk with minimization of the haptor as recorded for *Leptocleidus.*

Rhabdosynochus-Anchoradiscus Group

Disposition of the two pairs of anchors in the dorsal and ventral portions of the haptor with individual (disarticulated or unfused) bars supporting their bases (e.g. species of *Cleidodiscus* and *Urocleidus*) is regarded as primitive in Tetraonchinae. In *Rhabdosynochus* Mizelle & Blatz, 1941, this condition exists except that the bars have become fused in their midportions (Mizelle & Blatz, 1941, figs. 9, 10). In the genus *Actinocleidus* this association of bars has progressed to the point of structural modification for articulation to each other (Mizelle, 1938, Pl. 3, figs. 41, 43). In addition the ventral bar and associated anchors have moved anteriorly and the dorsal bar and anchors have migrated to the ventral side of the haptor. Thus, these structures are anterior and posterior in species of *Actinocleidus* instead of ventral and dorsal in *Cleidodiscus* and

Urocleidus species. It is interesting to note that the haptoral hooks retain their original positions as observed in *Cleidodiscus* forms (Mizelle, 1938). In *Rhabdosynochus* and most species of *Actinocleidus* the anchors and bars are situated in the fleshy portion of the haptor. In some species assigned to *Actinocleidus*, however, these structures have become reduced in size and relegated to a relatively small protuberance in the center of the ventral surface of the haptor which surrounds it in an umbrella-like fashion with a haptoral hook situated in notches on the edge of the haptor (Mueller, 1936a, Pl. 12, fig. 6). The name **Clavanculus* n. gen. is proposed for inclusion of these species. Articulation of the haptoral bars together with associated changes perhaps reaches highest expression in the genus *Anchoradiscus* Mizelle, 1941. In these the bases of the anchors have developed sufficiently to practically obliterate the anchor shafts and are so large that they occupy the major portion of a lateral plane through the haptor (Mizelle, 1941, fig. A). The anchor points emerge from the lateral rather than the ventral surface of the haptor as in *Actinocleidus* species. Both bars are modified approximately to the same extent and attached to the sides of the anchor bases instead of the edge of the superficial roots of these structures.

Urocleidus Group

This assemblage includes species from the old genera *Aristocleidus*, *Haplocleidus*, *Onchocleidus*, *Pterocleidus*, *Tetracleidus*, and *Urocleidus* as originally defined (all of Mueller). After reviewing the species involved, it is considered sound to retain all of them in the genus *Urocleidus* Mueller, 1934, as emended by Mizelle and Hughes (1938), for the following reasons. Originally *Tetracleidus* was distinguished from *Urocleidus* by the presence of a vagina and from *Onchocleidus* in the possession of an accessory piece in the copulatory complex (Mueller, 1936a). Since three of the six species originally described in *Onchocleidus* did not possess a vagina and further an accessory piece has been observed in practically every species of *Onchocleidus* and probably exists in all of them, it is obvious that all of the forms in these three categories belong to a single genus, namely, *Urocleidus*, which has priority. *Aristocleidus* was proposed to include species essentially like those of *Tetracleidus* except for a discrepancy in the shape of the dorsal and ventral anchors (Mueller, 1936b). Since discrepancies in anchor shape also occur in *Cleidodiscus* and *Actinocleidus* species, *Aristocleidus* has no validity and becomes a synonym (in part) of *Urocleidus*. The old genus *Pterocleidus* Mueller, 1937, was distinguished as embracing *Onchocleidus*-like forms which possessed a "flat blade" arising near the distal end of each anchor shaft on the concave surface. Superficially this old category appears valid but the character involved is hardly of subgeneric much less generic level and in the author's opinion cannot be used for generic fission any more than the widespread occurrence of a spine on the posterior border of the haptoral bars of species in this assemblage. Similarly the old genus *Haplocleidus* Mueller, 1937, which was separated from *Onchocleidus* because of the larger size of the dorsal pair of anchors is without validity since some species of *Cleidodiscus* and *Urocleidus* possess anchors with size discrepancies which intergrade with the condition cited as a character of *Haplocleidus.*

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* The generic diagnosis is being published elsewhere.

The foregoing conclusions concerning the old genera *Haplocleidus* and *Pterocleidus* are based on the premise that genera must be based on characters of more than insignificant magnitude which alone are requisite for sound taxonomic interpretation of valid evolutionary relationships. Generic fission for mere convenience of the novice or because of the presence of a relatively large number of species contained in a given genus, is considered inexcusable.

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Alkaline Phosphatase and the Differentiation of Gonads in the Albino Rat[1]

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Introduction

Present day investigations in developmental anatomy are rightly more and more concerned with the events of differentiation at the biochemical level. Actually this is a return to descriptive embryology, but now of a far more subtle kind than the conventional record of unfolding tissues, organs and systems. That is, the events of visible structural and functional differentiation are anticipated and accompanied by a host of biochemical transformations. Experimental manipulation having created as many problems as it solved, the new task of the embryologist has been to identify the kinds and locations of the biochemical ingredients within differentiating systems, the order of their appearance, their interactions, transformations and permutations, and the catalytic agents which accompany them. To this end the sensitive techniques of immunology and radio-active tracers play important roles as do also a variety of cyto- and histochemical methods. Among the more reliable of the latter are those for the demonstration of the phosphatases.

This is not the occasion for a review of the variety of the phosphatases and the functions they perform (vide Moog, '46). Suffice it to say that of all these, alkaline phosphatase is probably the best known and clearly appears to play a part in differentiation (e.g., Moog, '44, and McAlpine, '51) and regeneration (Karczmar and Berg, '51). The present study is intended to link the patterns of distribution and concentration of this enzyme to already established descriptive and experimental analyses of the developing gonads of the albino rat (Torrey, '45 and '50).

Materials and Methods

The materials and methods employed in the morphological studies just mentioned are recorded in the papers cited. The observations on alkaline phosphatase derive from a complete and closely spaced series of embryos and postpartum stages of the rat prepared with the ultimate aim of a full delineation of the developmental pattern of the enzyme in all the organ-systems. The bulk of the series was prepared by and for Dr. R. J. McAlpine, formerly of the Indiana University Department of Anatomy, to whom I am indebted for the loan of the slides pertaining to this study. An additional 19 embryos covering the critical developmental interval of 11 to 16 days were prepared personally.

The method of identification of the enzyme was one involving a slight modification of the Gomori ('39) technique and recorded in full by McAlpine ('51). It need only be added that all interpretations have been made in full awareness of the limitations of the method (Stafford and Atkinson, '48; Novikoff, '51 and '52; Goetsch et al., '52). It is realized, that is, that with a method which reveals only 25-30% of the in vivo phosphatase, measurements have qualitative significance only; and with the potential error introduced by diffusion and adsorption identifications of precise intracellular distribution sites may be meaningless. However, the technique appears sufficiently reliable to validate determinations of relative amounts and distributions of the enzyme.

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[1] Contribution No. 570 from the zoological laboratories of Indiana University.

To envisage such relative amounts an arbitrary measuring scale has been set up as follows: "0" refers to complete absence of precipitate and thus of the enzyme whose presence and activity the precipitate indicates. "Minimal" refers to a minute amount of precipitate in the nuclear membrane and nucleolus of a cell with none in the cytoplasm. A small amount of indicator within nucleus and cytoplasm is noted as "1+". A dense precipitate in both nucleus and cytoplasm to a degree almost obscuring cell outlines is indicative of maximum amounts of phosphatase and is noted as "5+". Gradations between these extremes are given the values of "2+", "3+", and "4+".

Observations

The Coelomic Epithelium and Gonads

The developmental history of the gonads begins with the coelomic epithelium in embryos of 11 somites (10 days). At this time the cells comprising the epithelium form a continuous layer on the coelomic side only. Basally the cells exhibit long processes like those of the underlying mesenchyme and there is no basement membrane delimiting epithelial from mesenchymal cells. The epithelium and deeper mesenchyme are considered to be a unit all of which will ultimately be concerned in the establishment of a gonadal blastema (Torrey, '45). At this stage, and on into embryos with as many as 18 somites, the phosphatase level in epithelial and adjacent mesenchymal cells is essentially "0", but approaches the minimal level by reason of indicative precipitate in the nucleoli. In interesting contrast, however, those cells which may be interpreted as primordial germ cells exhibit phosphatase to a 3+ and 4+ degree (fig. 1). It may be noted in passing, since the germ cells represent a side issue not to be pursued in detail here, that in embryos of this age group (11-18 somites) the germ cells are found within the coelomic epithelium at anterior levels only. Caudally they lie in the yolk sac, yolk stalk and wall of the gut (fig. 1).

A definitive gonadal blastema is established in embryos of 25-29 somites (11 days). The manner of its buildup has been described previously

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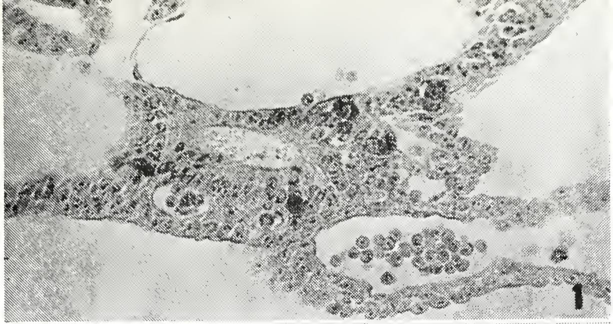
Fig. 1. Primordial germ cells, recognizable by phosphatase content, in gut and mesentery of 10 2/3 day embryo. x125.

Fig. 2. Blastema of 11-day embryo. Nuclei in "center" of blastema 3+ phosphatase, grading off to minimal levels in adjacent non-genital areas. x400.

Fig. 3. Blastema of 12-day embryo. Explanation in text. Arrow directed towards a germ cell. x400.

Fig. 4. Gonad of 13-day embryo. Explanation in text. Arrow directed toward a germ cell. x600.

Fig. 5. Testis of 14-day embryo. Cytoplasmic phosphatase up to 3+ level. Compare with figure 4. x600.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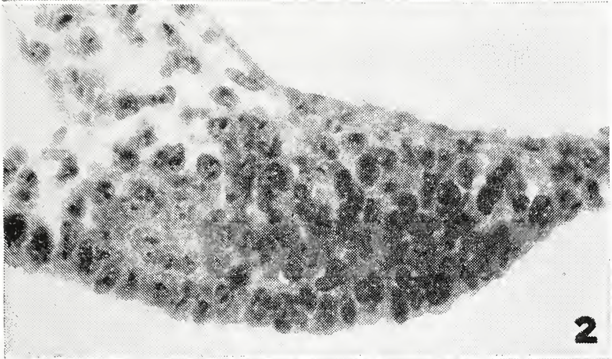
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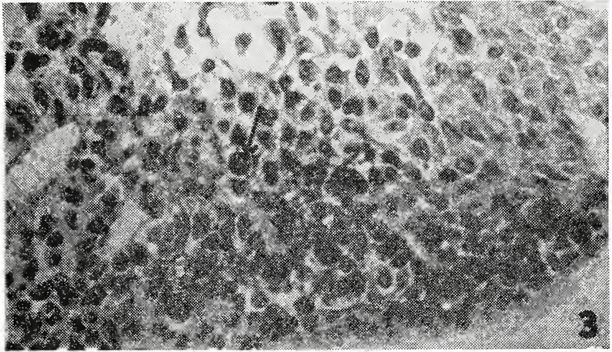
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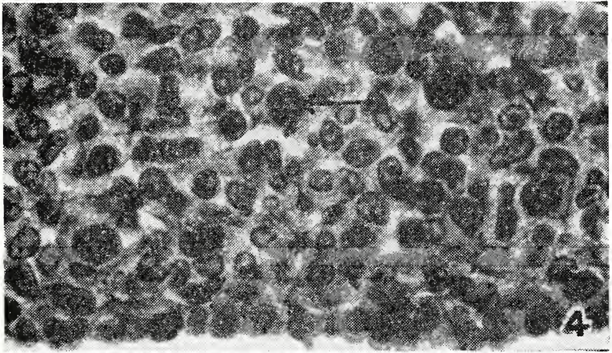
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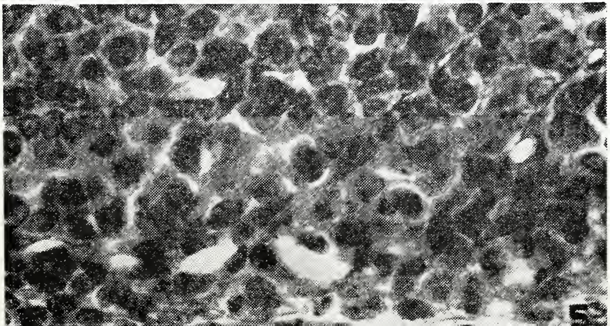
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(Torrey, op. cit.). Suffice it to say there now exists a primordium of sufficient bulk to be identified as a genital ridge. To the right and left of the ridge the coelomic epithelium is now clearly defined, whereas within the area of the ridge itself the epithelial cells blend with the general mesenchyme which in turn is not set off sharply from the adjacent nephrogenous tissue. The pattern of phosphatase distribution emphasizes these gradations (fig. 2). The nuclei of those cells comprising the "center" of the ridge show up to a 3+ concentration of enzyme with a gradual falling off to minimal levels in surrounding non-genital areas. The cytoplasm of all cells, however, appears to be devoid of phosphatase activity.

A gonadal blastema of considerably greater thickness is attained by embryos of 32-40 somites (12 days). The cells are now more closely packed and cell boundaries have become obscure. The gonad is essentially syncytial. There is still no basement membrane delimiting the coelomic epithelium and in routinely stained preparations the gonadal areas grade imperceptibly into the deeper non-gonadal mesenchyme. But the pattern of phosphatase distribution now makes the limits of the gonad considerably more obvious. It is not too difficult to determine the dorsal limits of the gonad in figure 3, for example, although the lateral boundary, grading as it does into the nephrogenous cells abutting the nephric duct, is still indistinguishable. A few primordial germ cells with large spherical heavily blackened nuclei are self-evident (fig. 3). The far more numerous somatic cells have smaller, irregular nuclei. These nuclei average about a 3+ concentration of enzyme; the somatic cytoplasm has now attained concentrations of 1+ to 2+.

Further thickening of the gonad is seen in embryos of 42-48 somites (13 days). Even in conventionally stained material the blastema is obviously sharply marked off from the deeper tissues and on the coelomic side the epithelium is becoming established. However, the matrix of the gonad is essentially like that of the immediately preceding stage: fairly compact with numerous germ cells with large nuclei and somatic cells whose nuclei are smaller and irregular. The phosphatase concentration in the large conspicuous nuclei of the germ cells is in the order of 4+ and that in the cytoplasm now more intense than before, about 3+ (fig. 4). The somatic cells show slight change, the nuclei presenting on the average a concentration of 3+ and the cytoplasm not less than 2+. This is the morphological and enzymatic status of the indifferent gonad. From this

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Fig. 6. Testis of 15½-day embryo. Explanation in text. x600.

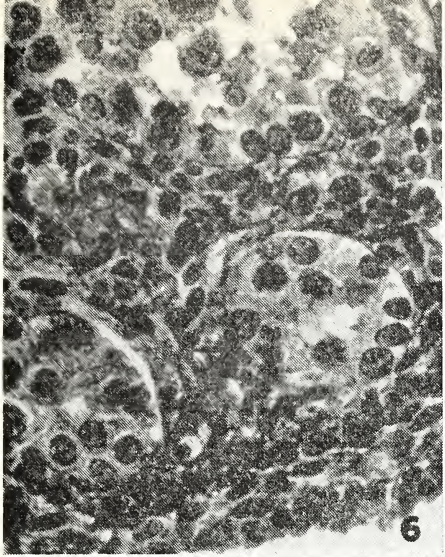
Fig. 7. Testis of 16½-day embryo. Note 5+ phosphatase level in tunica albuginea. x600.

Fig. 8. Testis of 19½-day embryo. Explanation in text. x400.

Fig. 9. .Three-day postpartum testis. x400.

Fig. 10. Ovary of 14-day embryo. Figure oriented with coelomic epithelium to right. Compare with figure 4. Arrow directed towards a germ cell. Note low reactivity of cells along coelomic boundary. x500.

Fig. 11. Ovary of 15-day embryo. Figure oriented with coelomic epithelium to right. Explanation in text. x500.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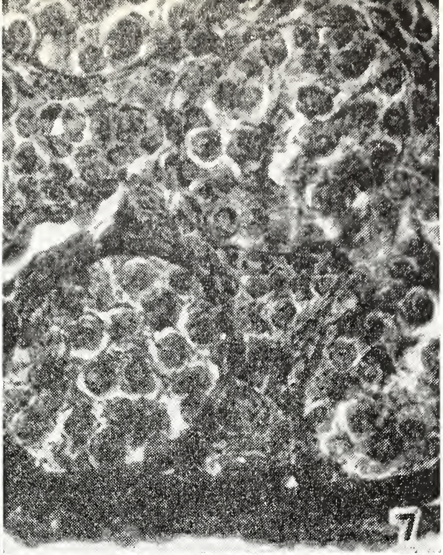
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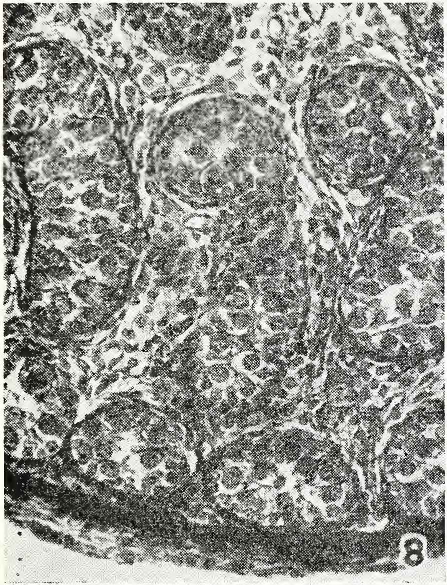
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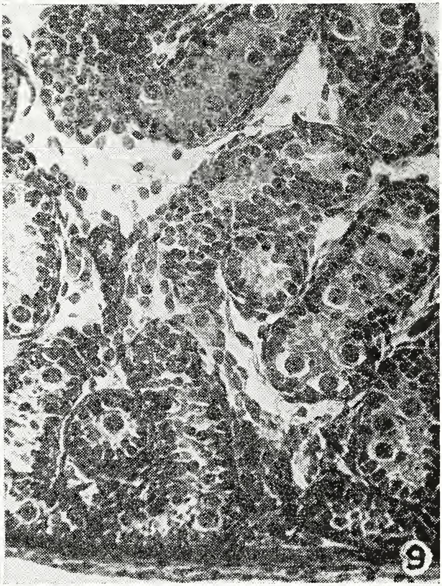
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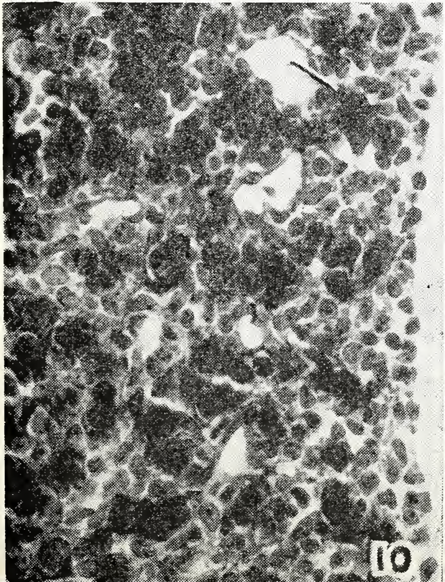
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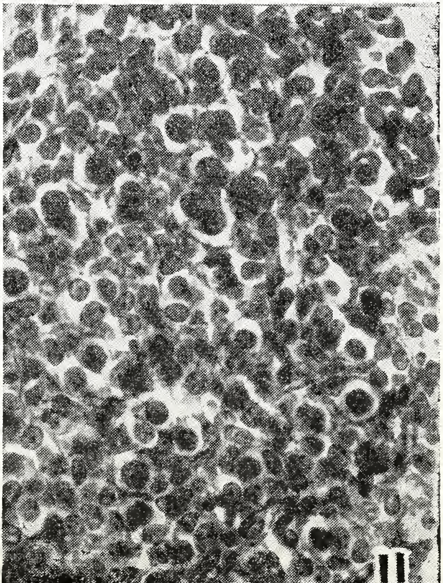
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time on sexual differences arise and it is thus convenient to consider separately the development of the testis and ovary.

The Testis

Gonads recognizable as testes are found toward the end of the 13th and beginning of the 14th day, varying with individual embryos. Primary sex cords are set off by the appearance of chromophylic membranes which serve to subdivide the original blastema (Torrey, '45). The coelomic epithelium is now complete and a prospective tunica albuginea lies between the epithelium and the peripheral ends of the primary cords. The essential modification of the phosphatase pattern concerns the primordial germ cells (fig. 5) which can no longer be distinguished so readily. Their nuclei are now reduced to a 3+ phosphatase concentration, putting them on a par with the somatic nuclei, and the cytoplasm is only slightly less. At the same time the cytoplasmic phosphatase of the somatic areas shows a rise to a 3+ level, thus the testis appears to possess a more uniform distribution of phosphatase than in the immediately preceding stage (compare figs. 4 and 5).

At 15½ days the primary sex cords are much more sharply defined and by the same token the interstitial areas and tunica are more conspicuous (fig. 6). The cords contain cells exhibiting considerable variation in nuclear size, shape, and phosphatase activity (fig. 6). The phosphatase concentrations of the nuclei range from 2+ to 4+ and it is now difficult to recognize germ cells. The gradations in nuclear size and the irregular granular appearance of some of the nuclei suggest the original primordial germ cells may be disintegrating and are destined to be replaced by a new generation somatic in origin. The cytoplasm within the cords has declined to levels ranging from 1+ to 2+. The cavitation of the cords in the case pictured in fig. 6 must be an artifact, for cavitation normally does not occur until the 15th day postpartum.

The general reactivity of the interstitial areas is higher than that of the sex cords (fig. 6). Many of the nuclei are blackened to a 4+ degree with the cytoplasm averaging 2+. The tunica shows an even more intense activity with the whole area approaching a 4+ level, and in an embryo just one day older (16½ days) the tunica and membranes delimiting the sex cords show a maximal phosphatase activity as evidenced by an intense 5+ blackening (fig. 7).

The changes in phosphatase content in the days immediately following are so gradual that to make them stand out let us pass abruptly to an embryo of 19½ days (fig. 8). Within the sex cords the nuclei show a 2+ concentration. There is still some gradation in size and shape of these nuclei, but the variations seem less than in embryos three days younger. The cytoplasm of these cells has now returned to a minimum level and only rarely can germ cells be identified with certainty. The interstitial cells, in contrast to the situation at 16½ days, now show a greatly reduced phosphatase concentration. Many of the nuclei are hardly more than 1+ with some approaching a 2+ level; the cytoplasm is 0 to minimal. The limiting membranes of the sex cords, however, range from 3+ to 5+ and the tunica is blackened to a 5+ level (fig. 8).

Testes of 3-day postpartum individuals present an organization which foreshadows that of the fully-formed gonads. The somatic cells of the testes cords are assembled as a regular epithelium and germ cells are once again conspicuous (fig. 9). The nuclei of both types of cells show a 2+ to 3+ phosphatase level while the cytoplasm is minimal. Interstitial tissues are now very diffuse with the nuclei at 1+ or less. The tunica albuginea, however, remains at 5+. In subsequent days only the limiting membranes of the cords and tubules and the tunica will show a high level of activity; the nuclei of the somatic and germ cells will show a decline to 1+ and below as will also the interstitial elements.

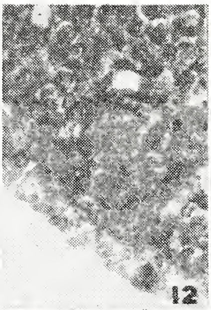
The Ovary

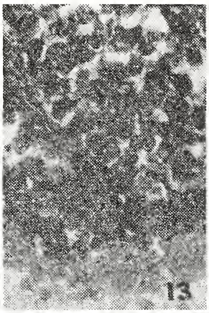
At the 14th and 15th days postcoitum ovaries are recognizable only in a negative way. That is, testes at this time exhibit characteristic structural features, thus gonads of this age which lack these features, appearing instead as indifferent gonads, may be presumed to be ovaries. They differ from the equivalent indifferent percursors of testes only in that they are somewhat more vascular (fig. 10). The primordial germ cells again stand out by reason of their larger nuclei with a 5+ concentration of phosphatase. The cytoplasm of these cells is 3+. The somatic cells, except near the coelomic border, show 2+ to 3+ for both their smaller, irregular nuclei and cytoplasm. The cells along the coelomic boundary are the least reactive, with no more than 1+ nuclei and 0 to minimal cytoplasm; they also lack a basement membrane setting them off as an epithelium and are devoid of associated germ cells (fig. 10).

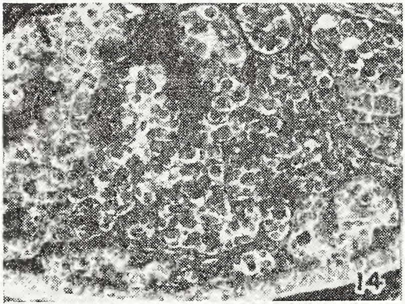
At 15 days (fig. 11) germ cells are still numerous, but their nuclei are less reactive (4+) and their cytoplasm down to 0. The somatic cells show a greater range of nuclear size, so while some are obviously distinct from the germ cells, others cannot be distinguished readily. Their nuclear reactivity ranges from 2+ to 3+ and the cytoplasm from 1+ to 2+. The lowest phosphatase concentration is again in the prospective but still unlimited coelomic epithelium.

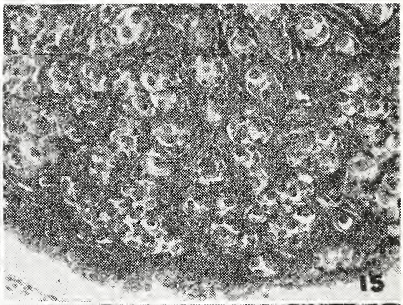
In ovaries of 16 to 16½ days primary sex cords are clearly set off by intervening connective tissue showing a 4+ reactivity (fig. 12). These primary cords consist of cells with 3+ nuclei and 1+ to 2+ cytoplasm. As before, some of the cells are obviously germ cells, but the gradations in sizes make a precise distinction between germinal and indifferent elements difficult. The coelomic epithelium is now quite distinct by reason of a generally low phosphatase reactivity, minimal to 1+ on the average for the nuclei and 0 to minimal for the cytoplasm (fig. 12). A basement membrane of about 3+ activity is just beginning to form. Where the membrane is absent, the cells of the mesothelium are continuous with and blend with the adjacent primary cords. Occasional germ cells with 3+ nuclei lie in the epithelium.

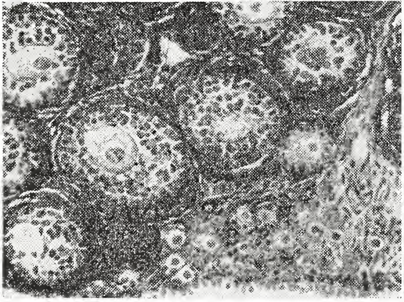
In the interval between 16½ and 19 days the germ cells, somatic cells, and connective tissue of the primary (medullary) area of the ovary become increasingly reactive. Thus in a 19½ day ovary (fig. 13) the interior of the gonad shows phosphatase concentrations in both nuclei and cytoplasm from 3+ to 5+. Many nuclei appear irregular and pycnotic











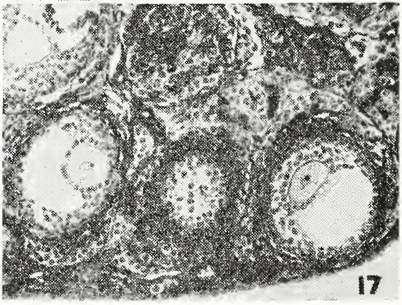


Fig. 12. Ovary of 16½-day embryo. Note low phosphatase content of coelomic epithelium (bottom) compared with that of primary cords. x500.

Fig. 13. Ovary of 19½-day embryo. Concentration of phosphatase in coelomic epithelium (bottom) low; in primary cords very high. x500.

Fig. 14. Two-day postpartum ovary. Explanation in text. x400.

Fig. 15. Five-day postpartum ovary. x400.

Fig. 16. Twelve-day postpartum ovary. x400.

Fig. 17. Sixteen-day postpartum ovary. Stratum granulosum shows low phosphatase level; that of theca very high. x400.

and one gets the impression of the start of a general breakdown of the interior. The basement membrane setting off the germinal (coelomic) epithelium is now complete and it, too, along with the septa separating the primary cords, is blackened to a 5+ degree. The germinal epithelium itself, however, shows a minimal reaction except at those sites where secondary (cortical cords) are being inaugurated (fig. 13). Both the nuclei and cytoplasm of the secondary somatic cells react to a 2+ to 3+ degree and germ cells with large 5+ nuclei may occasionally be seen.

From this point onward attention is centered on the secondary cords if for no other reason than the pattern of retrogression of the medullary elements of the rat ovary remains largely unknown. In the absence of this information, the pattern of phosphatase concentration and distribution would be meaningless.

A 2-day postpartum ovary is illustrative of the next events. The coelomic epithelium again shows a 0 to minimum phosphatase concentration and it is most interesting that the most recently formed cortical cords, namely those still connected with the epithelium, likewise show a minimal reaction (fig. 14). At deeper levels, however, the nuclei give a 3+ reaction although the cytoplasm has dropped to a minimum to 1+ level from the earlier high of 3+. Occasional cells with especially blackened nuclei may well be germ cells, but this identification is not certain. It is also difficult, at the deepest levels of the ovary, to determine where the secondary cords leave off and the primary cords begin. The membranes which bound the cords and delimit the germinal epithelium except at those points where it is continuous with newly forming cortical cords, are uniformly blackened to a 5+ degree (fig. 14).

The secondary cords of the 5-day postpartum ovary are beginning to be subdivided into nests of cells, the forerunners of the follicles. Such a fully delimited cluster consists of a central ovum enveloped by indifferent cells and separated from neighboring clusters by vascular and connective tissue (fig. 15). The nuclei of all the cells, germinal and indifferent, average about 3+ with the cytoplasm minimal. The septa range from 4+ to 5+; the germinal epithelium shows a minimal concentration.

The history of the ovary may be concluded with a brief consideration of 12-day and 16-day postpartum stages (figs. 16 and 17). The ova themselves show a uniformly 0 to minimal level of phosphatase. As for the developing follicles, the follicular cells at 12 days possess 3+ nuclei and minimal cytoplasm, but the surrounding tissues are 5+. So it is in those more mature follicles at 16 days (fig. 17). The ovum shows little or no phosphatase and likewise the cytoplasm of the stratum granulosum. The follicular theca, however, shows a phosphatase concentration of 5+. This is a pattern much like that reported by Corner ('48) for the mature follicles of human and pig ovaries.

Discussion

The observations just presented have pertained to a number of related but still somewhat distinct developmental events. Among these are the histories of the primordial germ cells, the tunica albuginea, and the interstitial cells as well as the somatic elements of the gonads. Except for recording the impression that the original stock of primordial germ cells disappears and is replaced by new generations of somatic origin, let us concentrate our attention on the sex cords and their precursors.

The essential facts with respect to phosphatase concentrations are summarized in table 1. Both nuclear and cytoplasmic values are recorded, but in the light of the strong possibility that nuclear "staining" may be an artifact (Novikoff, '52), the burden of the argument to be developed will be placed on the cytoplasmic values. These facts may be linked with profit to a previously acquired set of observations on the behavior of embryonic gonads in intraocular grafts (Torrey, '50). These observations and the conclusions derived therefrom are recorded in detail in the publication cited; the essential facts are likewise summarized in table 1.

There appear to be two principal correlations that obtain as one examines the record. First, acquisition of the ability of primordial materials to differentiate into testes or ovaries is accompanied by the rise of cytoplasmic phosphatase to a 3+ level. This is evidenced by: (a) the coelomic epithelium in embryos of 11-20 somites (10 days) with its 0-level phosphatase shows no ability whatsoever to differentiate in grafts; (b) the modest ability of 11-12 day primordia, showing a gradual rise to a 2+ phosphatase content, to form testes reaches a maximum in 13 and 14 day primordia whose phosphatase content reaches a 3+ level; and (c) determination of secondary cords as manifested by the consistent appearance of ovaries in grafts is accompanied by a phosphatase concentration which approaches the 3+ level. Second, an earlier suggestion (Torrey, '50, pp. 46-47) that every gonad, no matter what its genetic predisposition, shows an initial bias towards maleness is supported by the developing pattern of phosphatase. That pattern is as follows: The initial rise in phosphatase, occurring in the interval between 12 and 14 days, involves the primary cords and it is at this time that determination in zygotic testes, as manifested by their performance in grafts, occurs. The same predilection towards maleness accompanying the 3+ level of phosphatase in the primary cords appears in zygotic ovaries, a predilection which if favored by a suitable environment such as the anterior chamber of the eye is carried through as an actual sex reversal. Not until the rise of secondary cords from the 16th day on and the buildup of their phosphatase content to a 3+ level does the developmental direction of zygotic ovaries shift towards femaleness. Prior thereto the germinal epithelium with its minimal enzyme content shows little or no ability to produce ovarian tissues.

Thus is the normal developmental order of appearance of primary and secondary cords and the time and degree of their determination as measured through grafts accompanied by a pattern of phosphatase development. Viewing that pattern, one sees a strong suggestion that the events of determination are accompanied by a pronounced increase in the cytoplasmic content of alkaline phosphatase. For the moment one can only speculate on the role played by the enzyme in these events of biochemical differentiation. There is, of course, the frequently mentioned possibility of a link between phosphatase and the nucleic acids RNA and DNA in the mechanisms of phosphate transfer related to the variety of metabolic operations probably involved (e.g., Kutsky, '50). That this is not unlikely is suggested by the steady rise of these three agents during the development of Amblystoma (Krugelis, Nicholas, and Vosgian, '52). For the time being, however, it seems wiser only to record the correlation between high levels of cytoplasmic alkaline phosphatase and the occasion of determination in the primary and secondary primordia of the gonad,

TABLE 1

Age in Days	Primordium		Nucleus	Cyto- plasm	Behavior in Grafts (From Torrey, 1950)
10	Coelomic Epith.		0	0	No gonad differentiation
11	Blastema		2-3	0	Few scattered testis cords (3 of 21 grafts)
12	Blastema		3	1-2	Frequent testes (18 of 29 grafts) Rare ovaries (2 of 29 grafts)
13	Indifferent Gonad		3	2	Testes (47 of 79 grafts: 13 "converted medullary tubules" of genetic ovaries and 34 genetic testes) Ovotestis (1 of 79 grafts) Ovaries (3 of 79 grafts)
14	Testis		3	3	
	Ovary	Primary Cords	3	3	
		Coelomic Epith.	1	min.	
15	Testis		2-4	1-2	
	Ovary	Primary Cords	2-3	1-2	Ovotestes (4 of 17 grafts) Ovaries (5 of 17 grafts) Testes (4 of 17 grafts: "converted medullary tubules")
		Coelomic Epith.	1	min.	
16	Ovary	Primary Cords	3	1-2	
		Coelomic Epith.	min.-1	0-min.	
	Testis		2	min.	
19	Ovary	Primary Cords	3-5	3-5	Ovaries only (10 of 11 grafts)
		Secondary Cords	2	2-3	
		Coelomic Epith.	min.-1	min.-1	
2PP	Ovary	Secondary Cords	3	min.-1	
		Coelomic Epith.	0-min.	0-min.	
3PP	Testis		2	min.	
5PP	Ovary	Primary Follicle	3	min.	
		Coelomic Epith.	min.	min.	
12-16PP	Ovary	Stratum gran.	3	min.	
		Theca	5	5	

leaving the answer to the ultimate meaning of this to subsequent studies.

Whatever that answer turns out to be, the enzyme appears to play only a transitory role, for its concentrations drop to minimal levels once visible differentiation sets in. What new patterns of concentration and distribution may rise to accompany the later functional anatomy of the maturing gonads is beyond the scope of this study, except to take note of a high-level concentration of the enzyme which appears to presage the degeneration of the ovarian medulla.

Summary

1. The patterns of concentration and distribution of alkaline phosphatase are linked to a previously established descriptive and experimental analysis of the development of the gonads of the albino rat.

2. Acquisition by the primordial materials of the ability to differentiate into testes or ovaries is accompanied by a pronounced increase in the enzyme content of the cytoplasm. Once visible structural differentiation sets in, the concentration of phosphatase declines.

3. Every gonad, no matter what its genetic predisposition, first acquires testis-forming potentialities as evidenced by a phosphatase rise in the primary cords. Prospective ovaries develop as such only after a phosphatase rise in the later appearing secondary cords.

4. Incidental observations suggest: (a) that the original stock of primordial germ cells is replaced by new generations of somatic origin; and (b) that a very high-level concentration of phosphatase presages degeneration of the ovarian medulla.

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Spring Migration of Salamanders

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Three species of ambystomid salamanders *(Ambystoma jeffersonianum, A. maculatum* and *A. tigrinum)* were studied during the spring of 1953 and 1954. Mass breeding migrations of these ambystomids have been reported many times, but quantitative data are lacking. The area under observation is located in Rum Village Woods, St. Joseph County, Indiana. This study was limited to one pond (maximum in spring—2½ feet deep, area 0.3 acres) and its drainage area of 5 acres in a mixed, subclimax forest. Leaves, branches and logs as well as living trees and shrubs were common throughout the pond. In summer one-fourth of the pond supported a dense stand of grass and the remaining portion was covered with *Lemna minor.* The sloping, drainage area was covered in spring with about 2 inches of litter. Many depressions had a foot or more of debris. The subterranean region was perforated by small mammal tunnels and other cavities formed by the massive root system of the trees and shrubs.

Methods

In order to collect the majority of the salamanders before they entered the pond, a fine, wire screen fence (8 to 10 inches high and buried 2 inches in the ground) was built around the pond a few feet (average 10 feet) outside the water edge. All debris was cleared away for 2 feet on each side of the fence. The salamanders were collected along the fence; identified; sexed; then released in the pond. Representative collections in 1953 were weighed, measured and marked (metal tags or toe-clipping).

Discussion and Results

The salamanders traveled both over and under the litter en route to the pond, often stopping for short periods of time in depressions and pools. No eggs were laid in the pools. The fence was a temporary barrier to the salamanders. All of the heavy migrations (Table I) occurred during periods of considerable rain and between 7 p. m. and 2 a. m. The temperature of the forest litter during these active migrations ranged from 42° to 52° F.

It cannot be stated with certainty that all the salamanders came from the five-acre drainage area of the pond because no fence or trap was placed along the drainage divides. However, observations during the heavy migrations revealed no salamanders crossing the divides and there were other suitable ponds in the vicinity which supported equally as many adults during the breeding period. Also, adults were collected in the fall and winter from the runways and cavities in the drainage area. It can be stated with certainty that three species of ambystomids totaling a minimum of 415 individuals in 1953 and 224 in 1954 entered the 0.3 acre pond during the breeding period. Sufficient breeding niches were perhaps available for the three species. The ambystomids fed little or not at all during the actual breeding period. The food supply was plentiful for these top-predators during the period of feeding in the pond following breeding.

There were no fishes in the pond. The numerous, rapidly growing larvae which soon assumed the role of top-predators in the community probably experienced much greater inter- and intraspecies competition than the adults while in the pond. Also, the adults were in direct competition for food and shelter in the terrestrial habitats. Nevertheless, these data supplemented by the work of Manion and Cory (Unpublished dissertation, 1952) indicate that these species of ambystomids are established in the community and that the number of individuals (adults) in the three species remain in about the same ratio. Additional research must be done before the competitive factors can be understood. Likewise, of great interest are the sex ratios (Table I). These data indicate almost a complete absence of male *A. jeffersonianum*, a predominance of male *A. maculatum* and about equal numbers of male and female *A. tigrinum.*

TABLE I

Population Data and Dates of Migration to the Pond

	Ambystoma jeffersonianum		*Ambystoma maculatum*		*Ambystoma tigrinum*	
1953	♂	♀	♂	♀	♂	♀
March 11	0	1	0	0	2	1
March 12	1	36	159	35	8	7
March 14	0	16	85	24	7	3
March 15	0	0	0	1	0	1
March 22	0	2	0	24	1	1
Subtotals	1	55	244	84	18	13
Totals	56		328		31	
Grand Total						415
1954	♂	♀	♂	♀	♂	♀
March 19	0	4	0	0	0	0
March 20	0	0	2	0	0	1
March 24	0	9	127	45	5	8
March 25	0	2	1	1	0	0
March 28	0	0	0	0	1	0
April 10	0	3	6	5	0	4
Subtotals	0	18	136	51	6	13
Totals	18		187		19	
Grand Total						224

The decrease in total number of salamanders in 1954 (Table I) was in part the result of an extremely dry summer. The habitats suitable for feeding and shelter of adults were greatly reduced. This pond, as well as all other ponds in Rum Village Woods, was dry by the latter part of July which may have killed part of the crop of young salamanders; however, since the majority of ambystomids in this region do not breed the first year, the loss of any 1953 young would not be reflected in the spring migration of 1954.

The weight and length measurements (Table II), were taken before the salamanders entered the water. The females of *A. maculatum* were about 10 mm. longer and one-third heavier than the males. The mean lengths of the male and the female *A. tigrinum* were nearly equal, but due to the very large egg mass, the females were much heavier. All of the females of *A. jeffersonianum* were large; more than 148 mm. in total length; a mean weight of 14.7 grams.

TABLE II

Weight and Length Measurement

Species	Sex	No.	Total Range	Length (mm.) Mean	Weight (gms.) Range	Mean
Ambystoma maculatum	♂	81	135-215	166.6	8.5-28.0	17.5
	♀	11	156-197	178.3	11.4-33.2	24.1
Ambystoma tigrinum	♂	6	205-257	220.8	27.3-51.3	36.5
	♀	4	190-240	220.0	40.9-74.2	57.5
Ambystoma jeffersonianum ...	♀	7	148-175	163.0	11.9-16.6	14.7

Thirty-five salamanders were marked by attaching a small metal tag to the dorsal tail muscles. No individual was recaptured with a tag, but a few indicated that the tag was lost and in the laboratory salamanders lose these tags in about 2 weeks. Toe-clipping seemed adequate for short periods of time, if done with great care; but could not be used for annual records. Regeneration and injuries hindered interpretation.

Using only the clearly marked individuals, the number of days between the date when each individual first entered the pond and the date when first recaptured along the fence after breeding were as follows: male *A. maculatum* one—9, one—10, three—19, six—27, one—33, and one—49 days; female *A. jeffersonianum* one—10 days; female *A. tigrinum*, one—10 days; male *A. tigrinum*, one—10, one—19, three—27, and one—29 days. The stomach contents of these salamanders were not examined. These data, observation of activity, and examination of other salamanders indicated that some individuals of each of the three species found shelter and food in the pond and the immediate vicinity for as long as 49 days. The fence did not confine the salamanders to the pond.

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Summary of the Distribution of Indiana Crayfishes, Including New State and County Records[1]

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The only major paper dealing with the crayfishes of Indiana is by Hay in 1896 (9). He listed 14 species including one *(Procambarus gracilis* Bundy) that has not yet been found in the state but which may occur in the extreme northwest portion of the state (it has been found in Chicago). Williamson (16) described a new species *(Cambarus ortmanni)* from Wells County, and Faxon (7) described a new sub-species *(Cambarus bartonii laevis)* to include the form listed by Hay as *Cambarus bartonii. Orconectes inermis* Cope, considered by Hay to be a synonym of *O. pellucidus,* is here listed as a distinct species. The discovery of *Carbarus bartonii robustus* Girard in Miami County brings the present list to a total of 16 species and sub-species.

Hay's paper summarizes well the knowledge of the distribution of crayfishes in Indiana up to 1895. In the present paper his records are taken as the starting point to which are added subsequent records as they have been published and new records in the author's collection. In the following list, the published records are listed by counties. The numbers in parentheses following each county refer to the papers which reported them. New localities are given as specifically as possible. The generic terminology follows Hobbs (10).

List of Species

1. *Procambarus blandingii acutus* Faxon. Knox (9), Kosciusko (9), Lake (9), Marshall (4, 5, 9), Vigo (9), Wells (16). New location: pond 1 mile s.e. of Roann, Wabash Co.
2. *Orconectes indianensis* Hay. Gibson (9), Dubois (9).
3. *Orconectes sloanii* Bundy. Crawford (9), Floyd (9), Jefferson (9), Orange or Crawford (7).
4. *Orconectes pellucidus* Tellkampf. Bartholomew (9), Crawford (9), Harrison (9), Jefferson (9), Lawrence (9), Orange (9).
5. *Orconectes pellucidus testii* Hay. Monroe (1, 9). New localities: Eller's Cave (collected by G. Thurow) and May's Cave, Monroe Co.
6. *Orconectes inermis* Cope. Crawford (2). New locality: small cave 4 miles n.e. of Mauckport, Harrison Co. (Collected by Sherman Minton, Jr.).

The above three species are the blind white cave crayfishes of Indiana. *O. inermis* was described from a small cave near Wyandotte Cave in 1872 (2). Many early writers supposed that it was just a variant form of *O. pellucidus* and included it in the records that way. Faxon (1898) observed that specimens of *O. pellucidus* from Lawrence and Orange counties seemed more like the *inermis* variety than the typical *pellucidus* from Mammoth Cave. Hobbs (1948) after examining specimens collected at the type locality is of the opinion that until further work is possible on this complex, *O. inermis* should retain its specific status. The discovery of a new locality for *O. inermis* supports the validity of its status as a distinct form, either as a separate species (as considered here) or as a sub-species of *O. pellucidus*. *O. pellucidus testii* is apparently restricted to a small area around Bloomington in Monroe County.

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[1] Contribution No. 576 from the Department of Zoology, Indiana University.

7. *Orconectes immunis* Hagen. Kosciusko (12), Marion (9), Marshall (4, 5, 9), Noble (9), Posey (9), Vigo (9), Wells (16). New localities: ditch 1 mile s.e. of Laketon, Wabash Co.; ditch 5 miles e. of Warsaw and pond ½ mile s. of Little Barbee Lake, Kosciusko Co. Old records for *O. immunis spinirostris* are included here as this is considered a normal variant of the typical form and not a distinct sub-species.

8. *Orconectes virilis* Hagen. Elkhart (9), Greene (7), Kosciusko, Wawasee Lake (9), Lagrange (9), La Porte (9), Noble (9). New localities: creek 2 miles n. of Wakarusa, Elkhart Co.; Adams Lake, Oliver Lake and Lake-of-the-Woods, Lagrange Co.; Little Long Lake, Noble Co.; Otter and Walters Lakes, Steuben Co.; Goose Lake, Whitley Co.; Hill Lake, Kosciusko Co.

9. *Orconectes propinquus* Girard. Boone (14), Brown (9), Carroll (9), De Kalb (6, 9), Franklin (9), Fulton (7), Grant (7), Greene (9), Knox (3), Kosciusko (7, 9, 12), La Porte (9), Marion (9), Marshall (4, 5, 9), Monroe (3, 9), Noble (9), Sullivan (9), Tippecanoe (9), Vanderburgh (7), Whitley (7). New localities: Yellowwood Lake, Brown Co.; outlet of Lake Manitou, Fulton Co.; many localities in Kosciusko Co.; McCormick's Creek and Richland Creek, Owen Co.; creek 2 miles n. of Wakarusa, Elkhart Co. This is the most widely distributed species in the state.

10. *Orconectes rusticus* Girard. De Kalb (6, 9), Franklin (9), Hamilton (3), Huntington (7), Jefferson (9), Madison (3), Marion (8, 9), Orange or Crawford (3), Wells (3, 16), White (7). New localities: outlet of Lake Pappekeechie, Kosciusko Co.; Ball's Lake, Steuben Co.; Atwood Lake, Lagrange Co.; creek at Newton Junction near Laketon, Eel River near Roann, Paw Paw Creek near Roann, creek in city park, Wabash, Wabash Co.; Silver Creek near Liberty, Union Co. (collected by B. G. Owen). There is some variation between the northern and central specimens of this species. Work with a bigger collection might establish some sub-speciation.

11. *Orconectes juvenilis* Hagen (=*putnami* Faxon). Harrison? (9), Franklin (9).

12. *Cambarus bartonii laevis* Faxon. Floyd (7, 9—given by Hay incorrectly as New Albany, Jefferson Co.), Lawrence (9), Marion (7, 9), Monroe (1, 7, 9), Orange (9). Mitchell County of Ortmann (13) is undoubtedly Mitchell, Lawrence Co. New localities: McCormick's Creek Park, Owen Co.; small cave 4 miles n.e. of Mauckport, Harrison Co. (collected by Sherman Minton, Jr.).

13. *Cambarus bartonii robustus* Girard. New locality: Sulfur Springs Park, 5 miles s.e. of Peru, Miami Co. This is the first state record for this form. It is found commonly in southern Michigan and in Ohio. Dr.

Horton H. Hobbs, Jr., of the University of Virginia, graciously identified these specimens for the writer.

14. *Cambarus ortmanni* Williamson. Wells (16). New localities: Somerset, Wabash Co.; 4 miles s.w. of Roann in Miami Co.; Sulfur Springs Park, 5 miles s.e. of Peru, Miami Co.

15. *Cambarus diogenes* Girard. Boone (14), Crawford (7), Hendricks (9), Henry (9), Howard (9), Kosciusko (12), Lake (9), Marion (9), Marshall (7), Monroe (9), Noble (9), Putnam (9), Wells (16), White (7). New localities: creek at Indian Village, Noble Co.; many localities in Kosciusko Co.; creek 2 miles s. of Wilmot, Whitley Co. (Williamson, 15, reported burrows but no specimens for Round and Shriner Lakes, Whitley Co.); Somerset, Wabash Co.; 6 miles s., 2 miles w. of Roann in Miami Co.

16. *Cambarus fodiens* Cottle (=*argillicola* Faxon). Floyd (9—given incorrectly as New Albany, Jefferson Co.), Knox (9), Marion (9), Monroe (9). New localities: pond 1 mile s.e. of Roann, Wabash Co.; creek 3 miles n. of Webster Lake, and pond and creek in woods 8 miles n.e. of Warsaw, Kosciusko Co.; Yellowwood ponds, Brown Co.

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A Preliminary Report on Bat Banding in Indiana

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The marking of bats with bands was initiated by Dr. Arthur A. Allen, of Cornell University, in 1916. Banding was conducted by several persons from this time, so that by the end of 1951 there were 33 active banders operating in the United States and Canada (1). Norman C. Negus, Ohio State University, was the first to band in Indiana and tagged 286 bats in Big Wyandotte Cave, Crawford County, in 1946. The authors obtained permits in the fall of 1951 and to date have banded over 6,000 bats.

Bands are supplied by the United States Fish and Wildlife Service and are small, aluminum bands identical to those used on birds. Each bears a number made up of two parts, that is, a series designation and a group of 5 or 6 additional digits, such as 21-90407 or $\overset{54}{561238}$. Records are kept by the Section of Distribution of Birds and Mammals, U. S. Fish and Wildlife Service, under the supervision of Dr. John W. Aldrich. Bands are applied to the forearm of one wing of the bat in such a manner that they are free to slide along the radius and not pinch the skin.

Dr. Donald R. Griffin (2) gives as the major objectives of bat banding the determination of whether bats have a homing instinct, whether the same individuals utilize the identical summer and/or winter roost each year, and to trace the movements of individuals. Other objectives include determining the life span, sex ratios, phases of life history, physiology of hibernation, and parasites. Our banding in Indiana has been primarily concerned with movements, sex ratios, and the annual return of bats to identical roosts. Incidental to these aims have been the determining of bat populations, distribution, species composition, breeding range, and additional general knowledge regarding our native species. We are particularly interested in tracing the movements of *Myotis sodalis*, the Indiana bat, since its summer home is unknown. It was first described to science in 1928 from specimens taken in Big Wyandotte Cave, but has a wide distribution throughout the eastern United States.

Banding operations the past three winters have been greatly aided by the cooperation of many Earlham College students and a few other interested persons. Their invaluable assistance is greatly appreciated.

Methods

Most of our banding has been done in winter, when bats are congregated in caves and are easily captured in large numbers. Twenty-three caves throughout the limestone area of south-central Indiana have been visited. There are literally hundreds of caves of various sizes, however, which we have been unable to visit.

An attempt is made to capture every individual in the cave, but the nature of most caves makes this impossible. Several people usually comprise the banding team and after a few trips become very proficient, enabling us to band several hundred individuals in a relatively short time.

It is important that the bats are not held too long in the gathering cages, since their metabolic rate (usually very low during hibernation) accelerates rapidly and they utilize a considerable portion of their reserve energy, once they are fully awake. Excessive periods of action during their interrupted winter state of torpidity may cause them to use too much of this reserve. If this long active period is followed by many weeks of cold weather, many may starve before insect food again becomes available.

Efforts have also been made to locate colonies outside of caves at all seasons and we have banded in seven of these. Summer roosts are more difficult to locate and usually result in fewer animals to band, therefore our sample to date is quite small.

All bats captured are counted, identified, sexed, and given a cursory examination for external parasites, pelage coloration, and abnormalities. Some have been weighed and measured for special studies. In summer colonies, the animals are aged by an examination of the finger joints of the wings. Bats taken from the caves in winter cannot be aged accurately.

Findings

Field work carried out to date has supplied us with considerable information, although our banding program is a long-term project. We have attempted to sample caves believed to harbor the greatest number of bats, but have been greatly disappointed in the small populations found. Our work has paved the way for more intensive investigations and has pointed up the areas where additional data are sorely needed. We should like to present some of the significant findings at this time.

Populations:

Judging from earlier accounts, we expected to find Big Wyandotte Cave fairly swarming with bats. Visits on March 7, 1953, and March 20, 1954, however, have shown that this cave contains not more than 10,000. This is the largest concentration we have located, although other caves harbor from a few to 5,000. Almost every cave visited in winter has contained a few bats.

Species Composition:

Twelve species of bats are known from Indiana, but by far the greatest number of wintering individuals are the various species of *Myotis*. We have found seven species in the caves during our studies. In addition, we have picked up the skulls of *Lasiurus borealis* (red bat) and *Lasiurus cinereus* (hoary bat) in a cave at Spring Mill State Park. *Myotis grisescens* (gray myotis) and *Corynorhinus macrotis* (big-eared bat) are also known from Indiana caves. Only the one remaining species, *Nycticeius humeralis* (evening bat) has not been found in our caves. A summary of 6,160 bats banded prior to July 25, 1954, is as follows: *Myotis lucifugus* (little brown bat), 3,756; *Myotis sodalis*, 1,400; *Myotis austroriparius* (Mississippi myotis), 29; *Myotis keenii* (long-eared myotis), 17; *Pipistrellus subflavus* (eastern pipistrel), 534; *Eptesicus fuscus* (big brown bat), 411; *Lasionycteris noctivagans* (silver-haired bat), 2; *Lasiurus borealis*, 11.

Discussion and Future Plans

Further banding may be a helpful aid in determining the summer range of the Indiana bat. We hope to band as many of this species as we can find. Over the years we hope to determine if bat populations are really decreasing steadily, as seems evident in some caves at this time. It is doubtful if we can formulate the cause of any decline, but annual, detailed data from individual caves are necessary as a starting point.

In order to obtain a larger sample of the bat populations in our caves, we hope to work closely with the various speleological clubs over the state. We shall supply these organizations, and other interested persons or groups, with mimeographed information on the identification of our most common bats. When available, specimens will be given to these clubs as further aids in identification.

Additional knowledge of summer colonies in needed, since we have little means of determining the species composition or populations of summering species. We hope that persons knowing about bat colonies will contact us, for such congregations are usually located by chance. Studies concerning the life histories of various species can be initiated when colonies become available for research.

In addition to our banding, we propose to compile data concerning the range, population, and seasonal dispersion of all species of bats in Indiana. Some information on food habits may also be obtained. This material will be published at a later date. Locality records and/or specimens of all bats captured would be greatly appreciated. These may be easily preserved, entire, in 80 per cent alcohol, or they may be made into study skins, with skulls separate. A questionnaire sent to all colleges and universities in the state revealed that very few bat specimens are in their museums, notable exceptions being Earlham College and Purdue University.

Our combined study collections contain some 232 specimens. These will form the basis for any detailed morphological studies. We are actively adding material, as further collecting is carried out. The northern half of the state is poorly represented, thus material from there would be valuable to us. Specimens have been of considerable aid in banding work in that they have made it easier to distinguish between similar species.

In conclusion, we urge anyone knowing of a banded bat to report the band number to us promptly. If it is possible to obtain the bat, in case it is dead or injured, this would be desirable. In reading the band number on a live animal, be sure that all of the digits on the band are noted. Sometimes it is difficult to read a band that has grown into the flesh of the wing, but this seldom happens. If the band can be read in its entirety, it is best then to release the bat, unless it is obviously unable to survive. Bands may also be reported to the U. S. Fish and Wildlife Service, Washington 25, D. C.

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The Regeneration of Heads on Opposite Ends of Long Pieces of *Dugesia tigrina*

M. R. Garner, Earlham College

The regeneration of lost parts of planarians is well known due to the classical work of Child and his colleagues. It has been the custom of the elementary biology class at Earlham College to begin the second semester's work by variously cutting pieces of planarians, usually *Dugesia tigrina* or *D. dorotocephala*, to watch the phenomenon of regeneration and the conditions under which it occurs. Usually the worms for the experiments have been purchased from a biological supply house and kept in the laboratory for several days to two weeks and the regeneration occurs completely along the line of expectancy.

This year (February, 1954), on the day before they were to be used, several very large, well-fed specimens of *Dugesia tigrina* were taken from beneath the ice of a nearby creek. These were kept in a refrigerator until time for use on the following day. Specimens were variously cut according to the desires of the students, but most specimens had their heads and tails removed. These animals were left in watch glasses at room temperature and watched daily for signs of regeneration for the next two or three weeks. The students were much surprised to find in 10 instances of some 75 cut specimens heads growing on opposite ends of long cut pieces, that is, animals with only heads and tails removed. They had been told of the possibility that heads might grow on both ends of short cut pieces from the middle of the bodies, but were unprepared for the phenomenon as it revealed itself.

Child, in his explanation of the gradient theory, points out that the process of cutting sometimes raises the metabolic gradient so that in short pieces heads at each end may reasonably be expected. In the case of the present animals the cutting plus the raising of temperature from that near the freezing point of water to normal room temperature would account for raising of the metabolic gradient of the tail end of the cut pieces so that heads instead of tails regenerated.

Inasmuch as the unexpected phenomenon occurred 10 times over, it did not seem to be due to an abnormality of the worms themselves. So far as is known to the writer, no previous record has been made of the conditions under which long cut pieces of *Dugesia tigrina* regenerate heads at opposite ends. This phenomenon is not at variance with the axial gradient theory of Child but in complete conformity with it. The rise in temperature and cutting of heads and tails appears to have a cumulative effect in raising the metabolic gradient to the point where heads can sometimes regenerate even at posterior ends of long cut pieces.

Effect of a Choline-Deficient Diet on the Host-Parasite Relationship of the Domestic Fowl and *Ascaridia Galli* (Schrank)[1]

JOSEPH F. MORAN, JR., University of Notre Dame

Diet has been observed to have a pronounced effect on the natural resistance of chickens to infections with *Ascaridia galli.* Much of this work has been concerned with dietary deficiencies of the vitamins of the B complex. Since the majority of these investigations was completed before all of the known vitamins of this group were recognized, much of the work is admittedly without precision.

Deficiency of choline, a member of the vitamin B complex, in chickens and turkeys (perosis) was first pointed out by Jukes (1940) and confirmed by Hegsted *et al.* (1941) and Hogan *et al.* (1941). Record and Bethke (1942) gave further evidence which demonstrated that choline was an essential growth factor as well as perosis preventive.

The importance of choline as a dietary essential suggested the present problem of the host-parasite relationship of choline-deficient chickens and *Ascaridia galli.*

Individuals of three groups of 25 ten-day old white leghorn cockerel chickens were each inoculated with 600 infective eggs of *Ascaridia galli.* Birds of group I were fed a synthetic choline-deficient diet; those in group II the synthetic diet supplemented with 0.2% choline chloride; and infected controls in group III a commercial starter ration. Ten birds (group IV) fed the commercial starter ration served as uninfected controls. Weekly weight records of all birds were made during the experiments. Twenty-two days after infection all of the birds were killed. The worms harbored by the infected birds were removed (Ackert and Nolf, 1929), counted and measured.

Chickens fed the choline-deficient diet showed a mean daily weight gain of 4.10 grams, while those birds fed the choline-supplemented diet showed an average gain of 7.16 grams/day. Infected control birds receiving a commercial starter ration showed a mean daily weight gain of 8.71 grams. This figure for the uninfected controls (on the same ration) was 9.95 grams.

Chickens on the choline-deficient diet were stunted throughout the experiment and developed perosis during the third week. Birds on the choline-supplemented diet showed a slower growth rate and lower mean weights after the third week than did the infected and uninfected control birds which they had surpassed in weight gain during the first two weeks.

Although there was no statistical difference between the mean *number* of worms recovered from the birds on the choline-deficient diet and that of those from the group on the choline-supplemented diet, the mean *length* of the worms recovered from birds of the latter group was significantly greater than that of parasites from the birds on the deficient diet (table 1). Since the presence of choline in the diet of one group was the most apparent variable it is suggested that the choline is a factor favorable to the growth of *A. galli*. The mean number of worms recovered from infected controls was significantly greater than that of worms from either group on the synthetic diet. There was no statistical difference between the lengths of worms recovered from the infected controls and those fed the choline-deficient diet, however, the worms from this group were significantly shorter than those from the birds on the synthetic choline-supplemented diet. It is doubtful that the short lengths of the worms recovered from the infected controls was a result of the crowding effect as only 15.7 worms per bird were recovered (table 1).

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[1] The author is indebted to Dr. K. B. Kerr of Dr. Salsburg's Laboratories, Charles City, Iowa, for a supply of *Ascaridia* eggs.

TABLE 1

Effect of choline-deficient and supplemented diets on chickens inoculated with 600 infected eggs of *Ascardia galli* at ten days of age.

Group Number and Type of Diet	Number of Birds	Mean Weight Gain (gm.)	Mean Number Worms	t[1]	Mean Length Worms (mm.)	t[1]	Quant. Index Burden
I Snythetic choline-deficient	25	131.6	0.92		2.89		2.66
				0.38		3.18	
II Synthetic plus 0.2 grams choline/100 grams of diet	23	229.0	0.61		7.47		5.56
				3.75		3.72	
III Commercial starter ration	25	298.6	15.36		2.44		37.48
				3.61		0.86	
I Synthetic choline-deficient	25	....	0.92		2.89		....
IV Commercial starter ration—*uninfected*	10	318.4	....		....		....

[1] A "t" value greater than 2.58 is significant at the 0.99 confidence level by the Student "t" distribution method.

A quantitative index of worm burden was computed as the product of the mean number and mean length of worms per 100 grams of mean weight gain from a given group of birds. On this basis the birds on the deficient diet had an index of 2.66 and those on the supplemented diet one of 5.56. Although the latter index is more than twice as great as the former, the difference is scarcely significant when both are compared with the index of 37.8 for the infected controls, which showed the best growth and greatest mean weight gains for infected birds.

Chickens fed the choline-deficient diet had a mean weight at death of 166.6 grams as compared to a mean weight of 265.2 grams for the birds which were fed the choline-supplemented diet. Infected controls had a mean weight of 315.5 grams at death, while the uninfected controls had a mean weight of 354.6 grams.

These data indicate that at the particular level of infection and age of birds at infection that the diet is of more importance than the natural resistance of the host in determining the quantity of infection.

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Toxicity Studies on One-, Thirty-, Sixty Day Old and Adult Stagnicola Reflexa

RAYMOND A. WOOD, University of Notre Dame

Precise toxicity studies on gastropods have been few. Those of practical importance (Chandler, 1920; Krull, 1939; Brackett, 1939) were of a field nature and/or lacked precise methods for the accurate comparison of toxicants used. Although Chandler (1920) also did laboratory experiments with different compounds involving different species of snails, he used percentages instead of molarities in preparing his solutions. His criterion of death was solely a lack of response to tactile stimulation and this together with the fact that some of his apparently dead specimens revived after removal to fresh water made his results rather questionable. Krull (1939) also failed to use molarities and in addition gave neither exposure periods nor information on the possible revival of treated snails. Brackett's work was primarily designed to test the toxicity of copper compounds on aquatic life, principally fishes. He found copper sulphate too toxic to fishes to be of practical value for the destruction of snails. He did observe copper carbonate to be of practical value for the destruction of snails in that it was effective against ten specimens of *Stagnicola emarginata* which comprised all of his experimental gastropod material. His studies included no observations on the revival of the treated snails. It is interesting to note that McMullen, Ishii, and Mitoma (1948) observed copper phosphate and tribasic copper sulphate to be ineffective on *Oncomelania nosophora* in Japan.

Tomcek (1951) working with one-day *Stagnicola reflexa* was the first to utilize definite periods of exposure to various test solutions, followed by consistent observations of the specimens after being returned to fresh water. Her solutions, however, were made on a percentage basis so that comparison of the toxicants is difficult. The present study was undertaken in order to make a comparative analysis of the toxicity of some chemical agents both common and uncommon as molluscacides.

This is the first work to utilize laboratory experiments that test the response of *Stagnicola reflexa* of several ages, to definite exposures of prospective toxicants expressed in moles per liter, accompanied by observations on lethal effects after removal of the exposed specimens to fresh water.

All the experimental animals were obtained from a common progenitor and raised in the aquaria at the University of Notre Dame. A total of 42 individual experiments were conducted utilizing 25,200 snails.

One-thirty- and sixty-day-old *Stagnicola reflexa* (Say, 1821) in individual lots of twenty each (same age) were exposed separately for 15, 30, 45, 60 and 120 minute periods to 1.5×10^{-4}, 1.9×10^{-4}, 4.8×10^{-4}, 2.44×10^{-3} and 4.88×10^{-3} molar solutions of copper sulphate, copper carbonate, magnesium sulphate, magnesium carbonate, sodium carbonate and sodium chloride. Breeding-stock adults in lots as given above were utilized terminally with only copper sulphate and copper carbonate because of insufficient numbers.

In preparation, a copper sulphate-to-water ratio of 1-500,000, expressed in moles per liter, was used as a point of departure since this concentration of copper sulphate was found most effective for elimination of snails by Chandler (1920), Brackett (1939), and McMullen (1941). The snails were placed in test tubes, closed with gauze to prevent escape; immersed in the various solutions, washed twice in tap water, placed in containers, provided with food and then observed 24 and 36 hours later for recovery.

Effects of copper sulphate on one-, thirty-, and sixty-day-old snails were similar. There was one hundred per cent survival after the maximum exposure period of 120 minutes in the 1.5 x 10^{-4} and 1.9 x 10^{-4} molar solutions, of this compound in all three age groups. Only in the 4.88 x 10^{-3} molar solution after 120 minutes was 100% lethality achieved for the one-day-old snails, while it only went as high as 85% in the other two age groups. In the case of exposure of the breeding-stock adults all were dead at the 36-hour observation in all of the above concentrations after removal to tap water.

Results with copper carbonate were markedly different. The adult snails were not as susceptible to this compound as they were to copper sulphate. One hundred per cent lethality was achieved only at the maximum exposure time (120 minutes) in the 2.44 x 10^{-3} and 4.88 x 10^{-3} molar solutions. In all the other groups the kill was directly opposite to that found in copper sulphate. Maximum lethality in these young snails was obtained in solutions as low as the 1.9 x 10^{-4} concentration. Therefore a far greater toxic effect is indicated for copper carbonate than in the case of copper sulphate. The fact that copper carbonate is practically insoluble in water makes this an interesting phenomenon.

The data from experiments with sodium chloride revealed a low toxicity as compared with that for the copper compounds. Lethality for the three age groups was spotty and did not vary directly as the exposure periods for a given age group, except in a general way in the highest concentration, for the one-day-old snails. Neither was there consistent increased lethality in a direct manner for ascending concentrations. Average lethality for all concentrations, however, varied directly with the age of the snails.

Sodium carbonate was observed to be relatively non-toxic. This was especially true with regard to the one-day-old snails in which there was no more than five per cent lethality for any concentration at any of the exposures. In the case of the thirty-day- and sixty-day-old snails the kill was slightly higher. It was found that most of the experimental organisms had migrated out of their containers. This experiment, repeated many times, produced the same effect and therefore suggests the presence of an irritant.

Results with magnesium sulphate show a comparatively strong tolerance for the magnesium ion by the thirty-day-old snails. Lethality was greatest in the one-day-old snails in which the kill rose to 85% in the sixty-minute exposure to 4.88 x 10^{-3} molar solution. The sixty-day-old specimens exhibited lethal effect less than those for the other two age groups. A similar migrating effect was observed with the use of this chemical as was exhibited in the case of sodium carbonate.

Magnesium carbonate is relatively insoluble, which is indicated by its low toxicity to *Stagnicola reflexa.* The snails in each age group survived most of the concentrations for all exposure periods. The 4.88 x 10^{-3} molar solution had the greatest effect on the thirty-day-old snails in which the maximum lethality reached 80% for the 120-minute exposure. The one-day-old snails were the least susceptible to this compound and the lethality in the sixty-day-old specimens was intermediate between that of the other two age groups.

The order of descending toxicity, based on the average lethality in all the concentrations of the compounds used for the one-day-old snails is as follows: copper carbonate (89.6%), copper sulphate (43.8%), magnesium sulphate (32%), sodium chloride (15%), magnesium carbonate (1.8%), and sodium carbonate (1%).

The order of descending toxicity, based on the average lethality in all concentrations of the compounds used for the thirty- and sixty-day-old snails is identical and as follows: copper carbonate (98.8%; 90.6%), copper sulphate (42.6%; 40.6%), magnesium sulphate (19.6%; 22.2%), sodium chloride (15.8%; 14.4%), sodium carbonate (13.8%; 5.4%), magnesium carbonate (13.6%; 4.6%). The descending order of toxicity for these two age groups is identical with that of the one-day-old snails except the places of sodium carbonate and magnesium carbonate are reversed. With regard to adult specimens, copper sulphate (100%) was much more toxic than copper carbonate (83.4%).

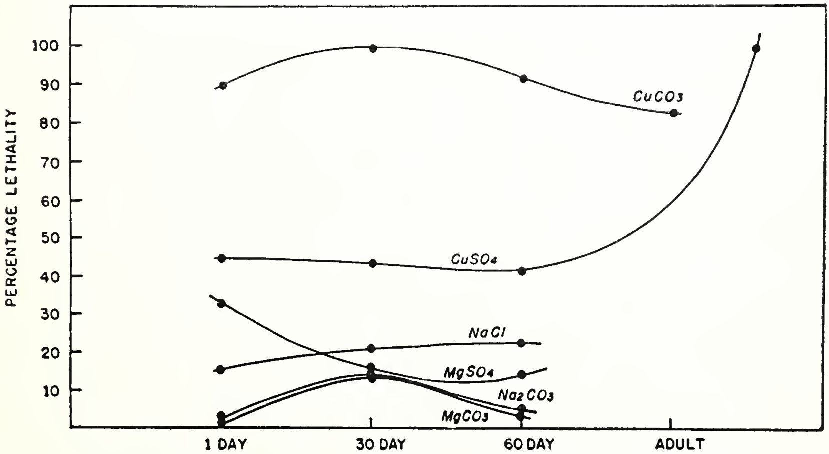

FIGURE 1.- AVERAGE LETHALITY FOR ALL CONCENTRATIONS AND EXPOSURES

The toxic action of the compounds used in this study is problematical. The solubilities and ionization properties of the salts indicate that the carbonate ion is relatively nontoxic. This is strikingly so for the one-day-old snails. On this basis, the high percentage of lethality which copper carbonate produced was attributable principally to the copper ion which does not follow in the case of copper sulfate which is a more soluble salt and also one which ionizes to a greater degree than copper carbonate. A plausible explanation would involve a difference in pH and the fact that the carbonate ion may act as a conditioner which would make the uptake of the absorption of the copper ion proceed at a much faster rate than in the presence of the sulphate ion. This is supported by the similarity of the toxicity curves (Fig. 1) and the marked discrepancy in the lethalities in copper carbonate and copper sulphate solutions.

With regard to the age susceptibility, the thirty-day-old snails exhibited a greater lethality than any of the other age groups exposed to copper carbonate and magnesium carbonate. Adult snails were more readily killed than were the younger ones in the copper sulphate solutions. The resistance of all subadult *Stagnicola reflexa* varied directly as the age with reference to magnesium sulphate concentrations and indirectly with age in the case of sodium chloride.

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Indiana Academy of Science members in good standing are eligible to submit papers for publication in the Proceedings. When a paper is signed by two or several authors, all must be members in good standing. Preferably, eligibility should be established before submitting the paper, as such papers are given priority. In any case, all authors must be certified by the Treasurer for payment of dues and old reprint bills at the time of the deadline (see below). Papers reaching the editor after the deadline are ineligible. All papers must be accompanied by an abstract in the form specified below, marked "for the editor."

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If the Divisional Chairman puts a paper on his program for the Fall Meeting, the abstract will be printed in the Proceedings regardless of the author's membership status, unless the full paper is published.

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1. Refer to Volume 59 of the Proceedings for the accepted style of abstracts and papers, and follow this, especially in **literature citations**, headings, and footnotes.
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15. The editor needs, at the time he mails out galleys in March, current addresses for all coauthors of all abstracts and papers. Many former graduate students lose the opportunity to order reprints when mail addressed to them is returned for lack of forwarding addresses. It is suggested that the student's permanent home address be written on the reverse side of that abstract copy marked "for the editor."

Selection of Papers

Every year a few more papers are submitted than can be published with the available funds. Therefore, not all papers received can be included in the Proceedings. Of those accepted, it is usually necessary that some be reduced in length by the authors, before publication. Manuscripts prepared concisely, in the style recommended above, will receive first consideration. Authors should not expect to publish very long papers in the Proceedings. Among papers of primarily regional interest, e.g., in certain aspects of botany, zoology, geography, and anthropology, those dealing with Indiana material will be accorded preference.

The selection of papers for the Proceedings is the responsibility of the Editorial Committee.

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